DTIC FILE COPY

SECURITY CLASSIFICATION OF THIS PAGE

AD-A221 070

)OCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1b. RESTRICTIVE MARKINGS
NONE

3. DISTRIBUTION/AVAILABILITY OF REPORT
APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

4. PERFORMING ORGANIZATION REPORT NUMBER(S)

5. MONITORING ORGANIZATION REPORT NUMBER(S)
AFIT/CI/CIA- 90-001D

6a. NAME OF PERFORMING ORGANIZATION
AFIT STUDENT AT Purdue University

6b. OFFICE SYMBOL (If applicable)

7a. NAME OF MONITORING ORGANIZATION
AFIT/CIA

6c. ADDRESS (City, State, and ZIP Code)

7b. ADDRESS (City, State, and ZIP Code)
Wright-Patterson AFB OH 45433-6583

8a. NAME OF FUNDING/SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (If applicable)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification) (UNCLASSIFIED)
Forecasting Air Base Operability in a Hostile Environment: Estimating Metamodels from Large-Scale Simulations

12. PERSONAL AUTHOR(S)
David Alan Diener

13a. TYPE OF REPORT
~~THESIS~~/DISSERTATION

13b. TIME COVERED
FROM ______ TO ______

14. DATE OF REPORT (Year, Month, Day)
1989

15. PAGE COUNT
367

16. SUPPLEMENTARY NOTATION
APPROVED FOR PUBLIC RELEASE IAW AFR 190-1
ERNEST A. HAYGOOD, 1st Lt, USAF
Executive Officer, Civilian Institution Programs

17. COSATI CODES

FIELD	GROUP	SUB-GROUP

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

DTIC
ELECTE
MAY 03 1990
S E D

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL
ERNEST A. HAYGOOD, 1st Lt, USAF

22b. TELEPHONE (Include Area Code)
(513) 255-2259

22c. OFFICE SYMBOL
AFIT/CI

DD Form 1473, JUN 86 *Previous editions are obsolete.* SECURITY CLASSIFICATION OF THIS PAGE

239

AFIT/CI "OVERPRINT"

Graduate School Form 9
(Revised 8/89)

PURDUE UNIVERSITY
GRADUATE SCHOOL
Thesis Acceptance

This is to certify that the thesis prepared

By David Alan Diener

Entitled

FORECASTING AIR BASE OPERABILITY IN A HOSTILE ENVIRONMENT:
ESTIMATING METAMODELS FROM LARGE-SCALE SIMULATIONS

Complies with University regulations and meets the standards of the Graduate School for originality and quality

For the degree of Doctor of Philosophy

Signed by the final examining committee:

co-chair

co-chair

Approved by:

Department Head

12-13-89
Date

This thesis ☐ is ☒ is not to be regarded as confidential

Major Professor

FORECASTING AIR BASE OPERABILITY IN A HOSTILE ENVIRONMENT:

ESTIMATING METAMODELS FROM LARGE-SCALE SIMULATIONS

A Thesis

Submitted to the Faculty

of

Purdue University

by

David Alan Diener

In Partial Fulfillment of the

Requirements for the Degree

of

Doctor of Philosophy

December 1989

ABSTRACT

Diener, David Alan. Ph.D., Purdue University, December 1989. Forecasting Air Base Operability in a Hostile Environment: Estimating Metamodels from Large-Scale Simulations. Co-chairs: Robert D. Plante and James R. Wilson.

An on-going Air Force logistics concern is the ability of an Air Force unit to fly aircraft into combat particularly when their air base comes under attack. Air bases are no longer sanctuaries; Air Force units must not only survive attacks but continue to operate afterwards as well. Limited budgets and long procurement and training pipelines magnify the problem, making it imperative to specifically identify and resolve support system deficiencies. A systems view of the support structure rather than narrow functional views is essential. We propose a simulation approach to the problem which attempts to capture the logistics infrastructure for a single air base. Multiple simulation runs are used to derive a simpler metamodel useful for forecasting future performance or for evaluating policy alternatives. This metamodel can then be used in lieu of complex and costly simulation models to explore "what if" analyses. Major research issues include the estimation of metamodels from large-scale simulation models with highly correlated responses, experimental design with simular responses and application of variance reduction techniques to large-scale simulation problems. Good variance reduction results are obtained using a classical two-level experimental design with blocking within the fraction based on common random numbers. Two cases, with and without attacks on the air base, are modeled as sub-experiments. Results indicate homogeneity of variance within each case, but heterogeneity between the two cases. A significant difference in the number of sorties flown when the air base is attacked is evident, but this difference dissipates by Day 30. The estimated metamodels indicate that two-way interactions are extremely important and should not be ignored. Also the daily metamodels differ not only in the slopes of the factors, but also in the very factors found to be significant. Many interesting insights into the complexities and interdependencies of the factors defining the logistics infrastructure are highlighted in this research.

To the men and women who daily prepare and study for war, not for its glorification or continuation, but for its prevention until the day

> They will beat their swords into plowshares and their spears into pruning hooks. Nation will not take up sword against nation, nor will they train for war anymore. Every man will sit under his own vine and under his own fig tree, and no one will make them afraid.
>
> (Micah 4:3-4)

ACKNOWLEDGMENTS

Many people have contributed to the success of this dissertation. Members of my committee have contributed in different ways. Dr. Timothy J. Lowe always encouraged me and believed in me from the very start of my doctoral program and I thank him for his support and example. The enthusiasm of Dr. James R. Wilson for simulation and academic excellence will always be remembered. His interest and guidance in researching this particular problem were invaluable. I thank him for his expert guidance with the analysis and for his many hours of wrestling with the TSAR computer code so we could run the model at Purdue. I thank Dr. Robert D. Plante for introducing me to many new ideas about experimental design and for whetting my appetite for research in that area. I also extend my thanks to the RAND Corporation for providing the TSAR/TSARINA models and databases. Mr. Don E. Emerson and Dr. John R. Folkeson of RAND willing contributed many hours of their personal time to help get the models running at Purdue University so that I could complete my research.

I also want to especially recognize Dr. Folkeson for his role in my education over the years. He was the first to encourage me to pursue a doctorate; this research stems from some ideas and work we brainstormed five years ago in a remote corner of the Pentagon. I highly regard his example as a scholar and gentleman.

My parents have also contributed tremendously to my being able to complete this doctorate. My father, Lt. Col. William E. Diener, instilled in me from "Day 1" to always do my best in all that I attempt. From him I have learned that sincere effort, dedication, and perseverance can many times make up for what I lack in talent. My mother, Jean L. Diener, taught me to be an individual, one with high personal standards and goals, not content with being mediocre. My sisters, Dianne, Denise, and Dorinda are also thanked for their many words of encouragement.

My wife and children have continuously supported me in accomplishing this task. Ann is the delight of my every day who never doubted that I would finish this and made many sacrifices so that I could. Derek and Karin often had to be without their Dad so he could "finish writing his book." I thank them for being quiet over the years so I could work.

Finally, I thank my Lord Jesus Christ for the blessings and talents He has provided that made this work possible. This is intended for His glory, not mine. To Him be the glory!

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CHAPTER I - THE AIR BASE OPERABILITY PROBLEM

Introduction

Air "force," as viewed by then Assistant Secretary of the Air Force, Tidal McCoy, consists of three elements: the air base from which aircraft launch and recover, the aircraft themselves, and the munitions that make the flying productive. All three are important and must be present for air "force" to exist. In recent years, renewed emphasis has centered on the air base itself and air base operability (ABO). ABO consists of interrelated and mutually supporting tasks: to defend, to survive, to recover, and to continue to fly aircraft (McCoy, 1987). Here we will focus on the last two tasks - to recover and continue to fly.

Air bases must be recognized as systems vulnerable to attacks which cause substantial resource losses. To ensure support for combat flying operations, managers must identify and resolve support system deficiencies. Given a support system view, what are the key resources and/or capabilities? Which are susceptible and sensitive to attacks? Questions such as these must be answered within an analysis framework which considers the interdependencies of the resources and functions comprising the logistics system of the air base.

Additionally, we must have a method to measure and compare different alternatives. A logical choice for a response variable is the number of sorties flown per day. A sortie is the flight of a single aircraft; the process of preparing an aircraft to fly is called sortie generation. The number of sorties flown per day (or some function of it) is a measure of how effectively the flying operation is proceeding and thus how well the logistics system works in support of the flying operations.

Typically the air base resourcing problem has been addressed independently by diverse functional areas while assuming other resources remain constant. For example, past efforts have been conducted by medical and personnel planners to predict the number of technicians (by specialty) required to fly certain sortie rates. Similarly fuel planners have examined the fuel requirements (quantities, storage needs, deliveries, etc.) necessary to meet wartime sortie rates. Similar efforts could be cited for munitions, aircraft, support equipment and so on. In such examinations of individual resource areas, no interdependencies are usually assumed. Approaches dealing with specific Air Force units have focused almost exclusively on the supply or spare part resource area (see Hillestad 1982, Pyles and Tripp 1982). While these include several of the major components of the logistics infrastructure, they still have a rather narrow focus and lack a total logistics system perspective.

Rich et al. (1987) discuss the need to focus on sortie generation in rapidly changing war environments and the importance of a total system viewpoint. The problem of projecting force capability in such stressful environments has taken two separate modeling approaches (simulation and analytic), each with its own inherent shortcomings. In brief, the limitations of both approaches include a) naive, overoptimistic treatment of inevitable uncertainties in demands for support, and b) simple mechanistic treatment of repair and distribution of parts. Further, the evaluation of sortie generation capability within a wide spectrum of resource postures in a combat environment has been difficult without a massive simulation effort.

The simulation approach to ABO issues has centered on the TSAR (Theater Simulation of Airbase Resources) model (Emerson 1982) and the TSARINA (TSAR Inputs using AIDA) model (Emerson 1980), both developed by the RAND Corporation for the U.S. Air Force. TSAR is a sortie generation model while TSARINA is an air base damage model.

TSAR was created with the interdependencies of air base resources as a focal point. The intent was to permit decisionmakers to explore the air base as a system in order to seek improvements to that system. Resource levels, logistics policies, environmental factors such as attrition, and operational tasking can all be varied while assessing the impact on sortie performance. Weak or deficient areas in the logistics infrastructure can thus be identified. A single air base can be simulated or an entire system of interdependent air bases can be modeled. The simulation also allows the air base to be attacked and the results of those attacks examined. Thus, applications of the model are broad and encompass a wide range of interest by many different users.

The TSAR model is a discrete-event Monte Carlo simulation which models 11 classes of resources. TSARINA is a companion model supporting the TSAR sortie generation simulation program. It calculates resource damage caused by attacks on the air base as well as toxic effects of chemical attacks. Many types of weapons can be simulated with uncertainties and randomness included. Figure 1.1 summarizes the relationship of the models and their primary features. Complete descriptions of both models and capabilities are found in Emerson and Wegner (1985).

The goal of this work is to gain more complete knowledge of an air base logistics infrastructure, through the TSAR/TSARINA simulation models, to extend the benefits of analytic models which are more adept at assessing large-scale systems. Certain objectives will guide us to this end.

Research Objectives

A major focus of this research is the use of simulation, through efficient experimental design, to identify and

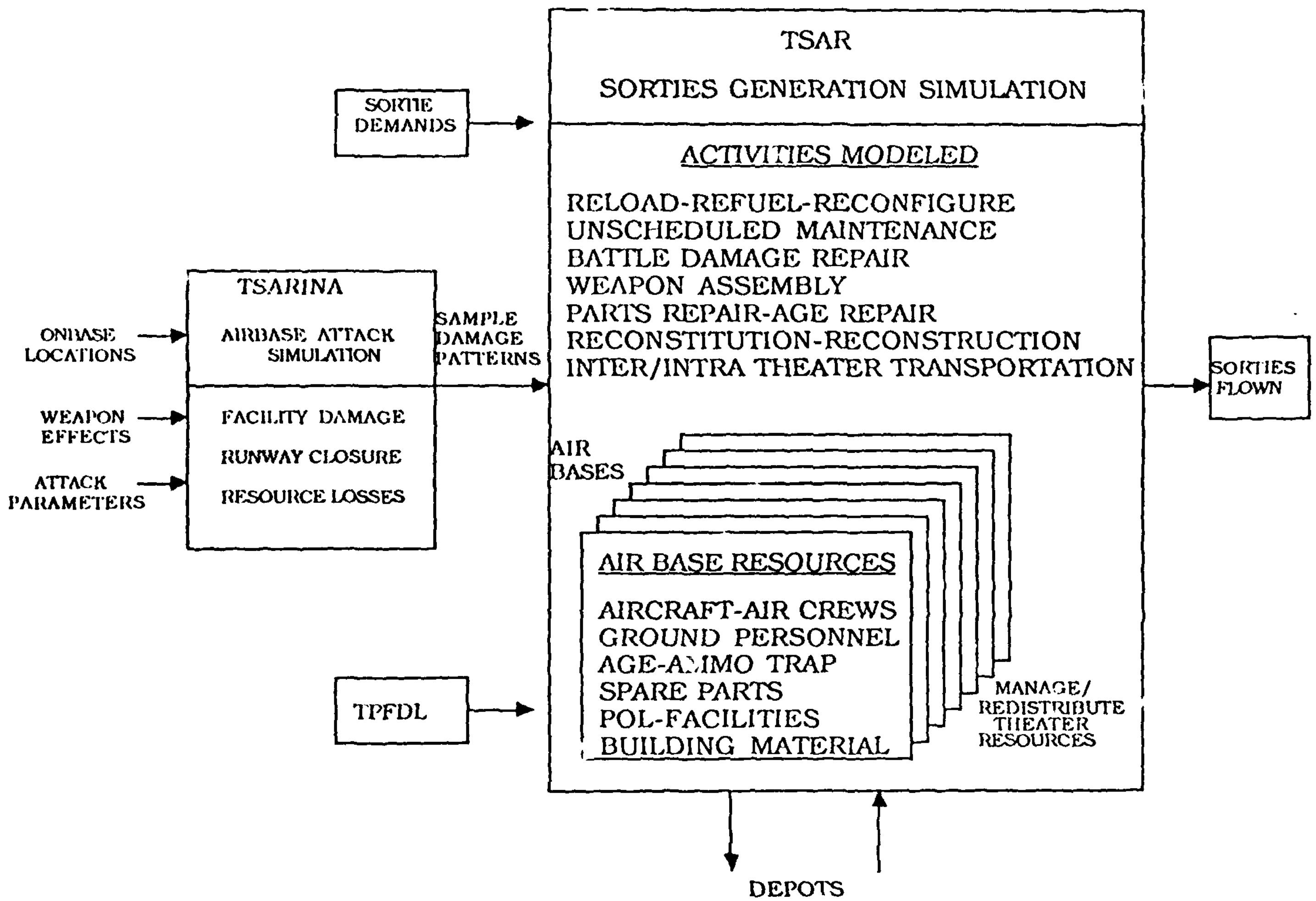


Figure 1.1

TSAR/TSARINA for Analyzing Sortie Generation Capability estimate parameters which can be used in analytic models. As discussed above, both simulation and analytic approaches have been followed in addressing the issues of ABO and logistics infrastructure. These approaches do not have to be exclusive; rather they can be complementary. The better and more efficiently we use large-scale detailed simulation models, the better our analytical models will be.

One of the purposes of a simulation is to gain insights and understanding of a real-world system. Although the simulation model is a simpler representation of reality, it can be very complex in and of itself. Thus an even simpler model may be used to better understand the complex model; this simpler,auxiliary model is often called a metamodel. Figure 1.2 depicts the relationship between the real-world, the simulation model, and the metamodel (Friedman 1984). Friedman (1984) provides numerous references for discussions of the relationships of analytic and simulation models, and the use of metamodels.

This research proposes to bridge the gap between simulation and analytic models by capturing the detail provided by a simulation model in a simpler metamodel which can then be used analytically to address capability questions. This provides a useful and analytically sound tool for decision-makers confronting ABO issues. Figure 1.3 captures the essence of the problem where simulation models are used to generate performance data based on the level of

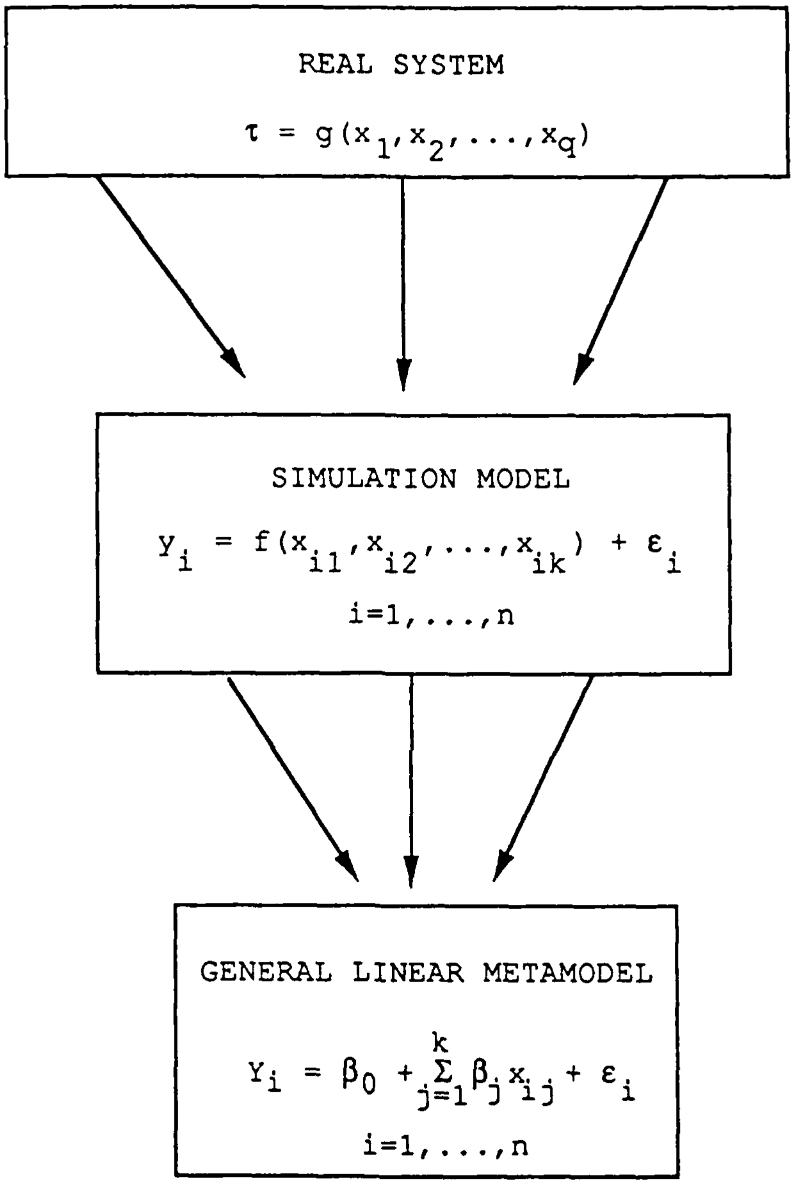
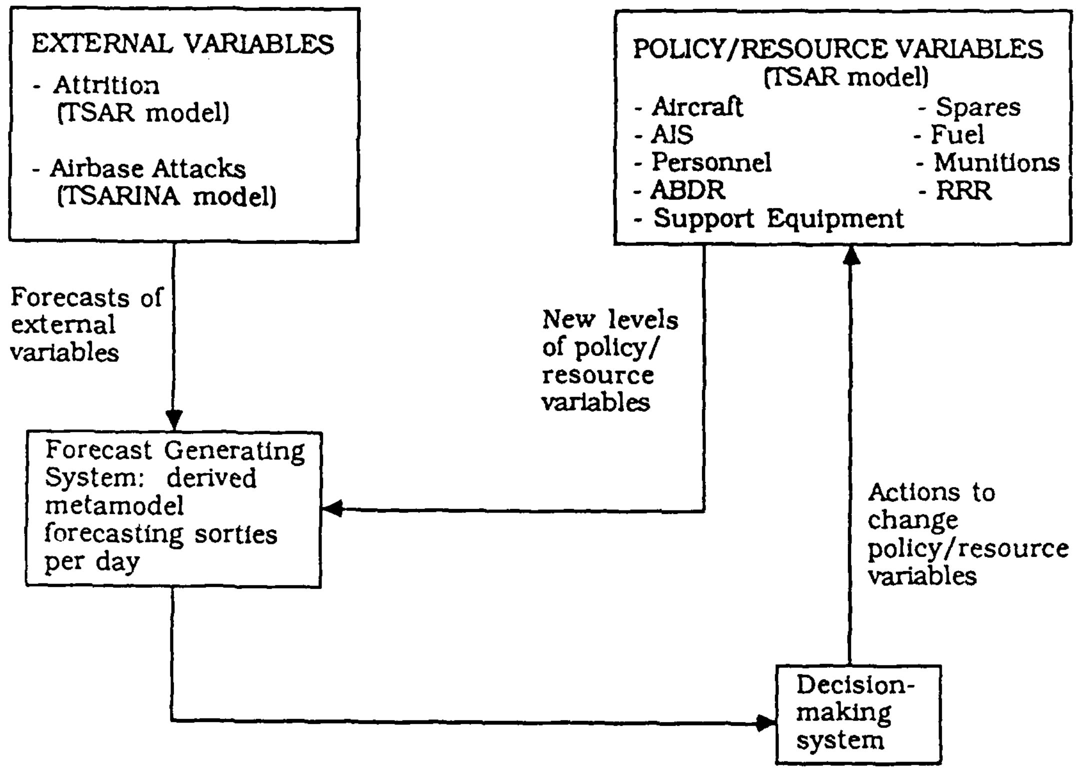


Figure 1.2

Single Response Simulation Analysis



ABDR - Aircraft Battle Damage Repair
AIS - Avionics Intermediate Shops
RRR- Rapid Runway Repair

Figure 1.3

Air Base Operability Framework

policy/resource variables and external variables. These data then will be used to estimate simpler metamodels that will become the forecast generating system. Once developed, the metamodels will be used with actual inputs of resource levels from the decision maker's system.

The specific research objectives can be stated as follows:

1) Efficiently apply an experimental design that will reduce variance due to the inherent randomness of the TSAR and TSARINA simulation models;
2) Estimate metamodels, with significant main effects and two-way interactions, from large-scale simulation experiments so that sorties flown can be predicted based on input factors;
3) Evaluate the impact of air base attacks on the number of daily sorties flown; and
4) Identify key resources and/or interactions over a thirty-day time period with and without air base attacks.

Organization of The Thesis

Chapter II describes the sortie generation process underlying the problem area and provides some background on various approaches to modeling sortie generation at an air base. Also we introduce some background on statistically controlled experiments where variance reduction is a concern.

Chapter III discusses the methodology involved in setting up the TSAR/TSARINA data bases and describes the metamodels to be estimated. Also we discuss the experimental design and how each research objective is to be measured.

Chapter IV centers on how well the design worked with respect to variance reduction and the estimated metamodels. It concludes with an evaluation of the impact of attacks on daily sortie counts.

Chapter V focuses specifically on the interpretation of the estimated metamodels. It concludes with an overall evaluation of the input factors in the case where the air base is attacked and the case where there are no attacks.

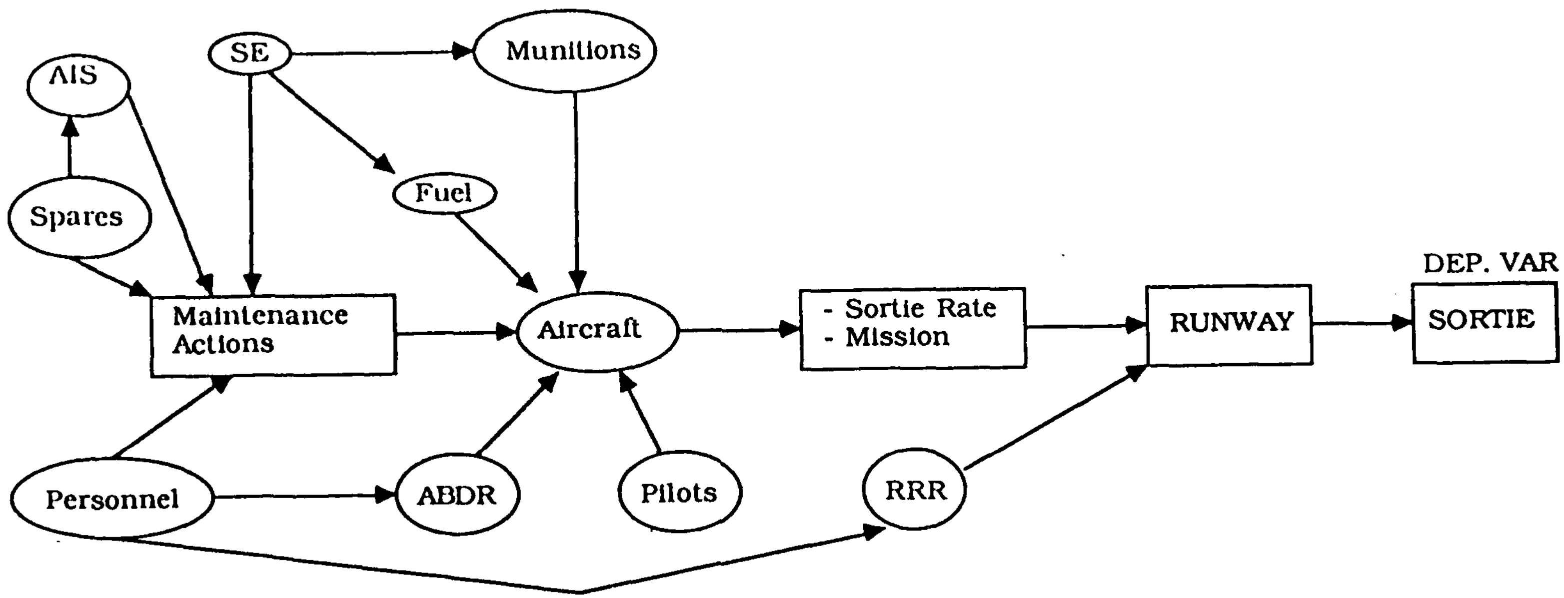
Chapter VI provides overall conclusions for this thesis. First, the scope of the research is discussed to emphasize the appropriate extendability of the results. Next, conclusions are presented for each research objective. Finally, limitations and corresponding future research are discussed.

CHAPTER II - BACKGROUND AND LITERATURE REVIEW

Necessary background for this research is an understanding of the sortie generation process, i.e., what resources, factors and processes are involved in flying sorties. This is presented first, followed by discussions of simulation and analytic tools used to model sortie generation of today's fighter aircraft. Next is a review and critique of a previous study which provides the backdrop for this work. Lastly there is a section on the underlying theory of statistically controlled experimental designs.

The Sortie Generation Process

The sortie generation process is complex with much inherent variability. Figure 2.1 captures the relationships of important factors in the sortie generation process at an air base. Figure 2.2 further extends the sortie generation process by including the dynamics of the resource interactions in an environment where the air base is vulnerable to attacks. Interdependencies among factors within the logistics infrastructure are evident in Figure 2.2. As a result we require a total systems perspective over time rather than simple one-factor-at-a-time analyses. The



ABDR - Aircraft Battle Damage Repair
AIS - Avionics Intermediate Shops
RRR - Rapid Runway Repair
SE - Support Equipment

Figure 2.1

Sortie Generation Process

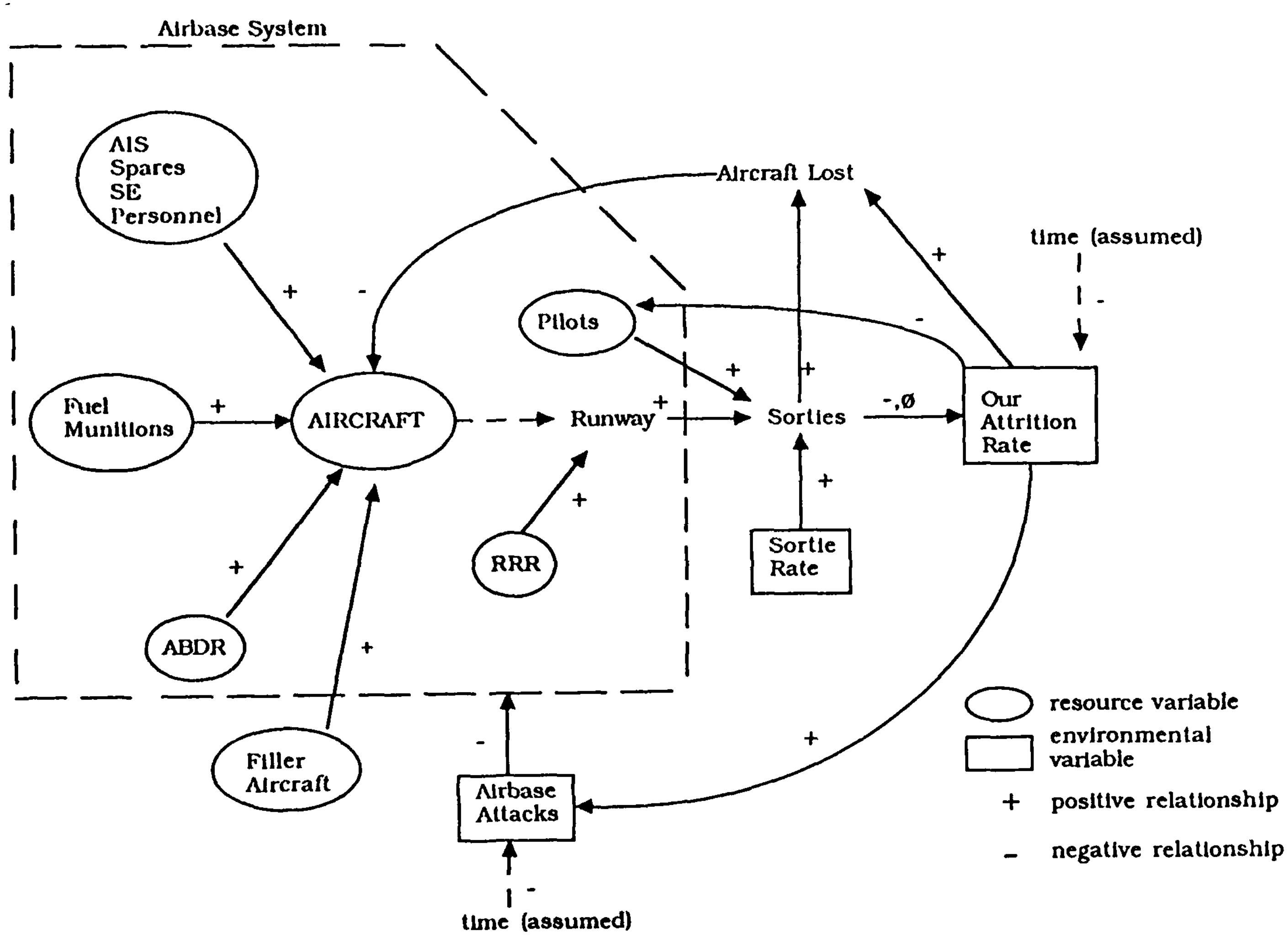


Figure 2.2

Sortie Generation Dynamics

interdependencies are not always easy or obvious to explain. For example, if we envision Figure 2.2 with several aircraft over many days, it is possible for a high level of flying in the first few days to lead to aircraft losses which result in flying fewer sorties later than otherwise would have been flown.

With sorties flown (or some function of this performance measure) as the response variable, we must deal with the prospect of highly correlated responses over time. From one perspective, we expect correlations on a day-to-day basis. In the absence of interventions, such as attacks on the base, the level of flying is logically related to the health of the logistics infrastructure. Thus it seems that if many (few) sorties are flown on a particular day, we would expect to also fly at the same level the next day. An exception is when heavy flying leads to large maintenance backlogs; many aircraft must be repaired and the flying drastically declines until the repair workload is reduced. This situation is generally short-lived and high levels of flying can resume following the recovery.

Another perspective considers that, given a wartime scenario, deliveries of resources will be extremely limited and basic logistics capabilities will not be enhanced within the first 30 days. As a result, future responses are necessarily related to that beginning posture on Day 1. Attacks on the air base further complicate the matter by creating nonstationarities and interruptions in the time series data. Here we expect the attacks to cause large initial degradations in performance which recover to some new level that is substantially less than the initial capability.

Sortie generation analysis problems arise from basically two sources: the nature of the data and the modeling of the sortie generation process. The simulation of the sortie generation process also involves certain considerations since it is a simpler representation of the real system. A major concern is the amount of variability inherent in the problem itself and how the modeling accounts for it. For example, how sensitive are the results to changes in the random number streams used by the model? How much variability is due to the nature of the process and how much to the model itself? An additional analysis issue is the possibility of nonconstant variance across design points when attacks are included. Folkeson (1986) indicates that this may be the case. Finally the problem is complicated since the simulation measures the resource levels only on Day 1. Thus we are dealing with indicator variables representing logistics policies, repair capabilities, expected delivery schedules, and resource levels as of Day 1, rather than trackable quantitative series for the independent variables.

Simulation and Analytic Tools for Modeling Air Bases

The TSAR and TSARINA models are prevalent in the detailed study of air bases via simulation. These models are described above. Additionally, other simulation and analytic models have been developed which are described briefly below. We also provide a summary of current ABO research being done with simulation tools.

Simulation Models

Sortie generation models other than TSAR have been developed for various reasons, but usually to answer specific questions or investigate particular areas of interest. As a result, none to date provide the detailed relationships modeled by TSAR/TSARINA which give it flexibility and overall applicability to many interests.

A less complex simulation was applied to a multilevel maintenance system to discover design parameters which optimize system performance (Chrissis and Gecan 1986). While a novel application, it is a simplistic and narrow functional view limited to the supply and repair of spare parts. Also, as the authors note, their approach is best applied to small systems since dimensionality is a serious problem as the size of the system increases. What is missing as a result is the invaluable insights into the complex interactions of the logistics system on the air base.

Hughes Aircraft has developed a model to evaluate various basing and logistics options for aircraft they are designing (Tinley, 1988). The intended use appears to be for the evaluation of rather broad issues such as levels of maintenance, main operating bases versus dispersed locations, spare part stockage levels, etc. Again, it misses the interactions and complexity of the logistics infrastructure.

While these efforts provide valuable insights to limited and specific questions, analysts continue to demand simulation which captures many functional areas simultaneously such as provided by TSAR/TSARINA.

A project recently undertaken by the Air Force includes an analytic treatment of the logistics processes within a simulation framework. The resulting model is called the Combat Base Assessment Model or CBAM (Hume, 1988). The purpose of CBAM is to provide a single, PC-based, easy-to-use tool to simulate attack, repair, and sortie generation at an air base. The developers describe the model as a "deterministic repeatable computational model" (Garjak, 1988). Since CBAM is intended to be run on a desktop personal computer, multi-trial results are not practical. Therefore CBAM simplifies the use of random variables by (a) replacing the random variable with a deterministic value based on the most likely value, (b) truncating distribution tails, (c) using selection criteria to limit choices, (d) stratifying outcomes from continuous distributions into discrete states, and (e) compressing distributions to make them more "spiky" (Garjak, 1988). This most-likely approach to simulation allows simplification, but also tends to fail in capturing the daily uncertainty and volatility within the logistics infrastructure in a wartime environment.

An Analytic Model

Analytic approaches have centered on the Dyna-METRIC (Dynamic Multi-Echelon Technique for Recoverable Item Control) model also developed by RAND (Hillestad 1982). The focus in these efforts is on the stockage and movement of reparable spare parts through the various levels of controlled inventory and maintenance.

The overall purpose of Dyna-METRIC is to relate aircraft spare parts inventory levels and maintenance capability to the readiness of aircraft. As described by Hillestad (1982), a key characteristic of the mathematical model is the ability to deal with dynamic or transient demands for spare part inventories and component repair caused by a changing environment. The model implements a set of analytic equations which capture the dynamic behavior of the component repair queueing system. From these equations, time-dependent inventories can be computed and related to aircraft capabilities to fly assigned missions.

Current ABO Research

Current ABO research efforts primarily use simulation as an analysis tool. For example, the Air Force is developing ABO reference manuals which describe the operational capability gained by adding certain ABO assets to representative bases (Hume, 1988). Based on TSAR simulations, these manuals will provide information for logistics planners.

Another TSAR-based study analyzes various ABO policies and attempts to capture the sensitivities of the dynamic wartime environment (Folkeson, 1988). A major focus in this effort is the variance of attack effects. Fifty different attacks are used when evaluating each policy. The emphasis is not so much on the detailed performance of the logistics infrastructure, but on the performance and survival of the air base system. Hence the focus is more on the "defend" and "survive" aspects of ABO rather than the "recover" and "fly" tasks that we are concentrating on in this paper.

Other work has used TSAR as a central tool for assessing the capability of an air base (Manger, 1988). A prototype model has been developed which consists of pre- and post-simulation data processors built around TSAR. These data processors use standard data systems to create TSAR databases for actual air bases using current data. The model produces sortie capability information and predicts problem resource items. Such a model could be used as an on-line real-world capability assessment tool.

A Previous Study of an Air Base Logistics Infrastructure

One study in particular addresses the overall air base resourcing problem from a total systems perspective.

Folkeson et al. (1986) used TSAR to simulate the air base logistics support system defined by nine resources which contribute to flying an aircraft. Figure 2.1 shows how these variables relate to the sortie generation process.

The Logistics Variables

Each of the nine variables was varied over three levels: high, medium, and low. This resource structure was subjected to a constant environment, i.e., the environment was not changed as the resource structure was varied. This environment included such factors as aircraft attrition (i.e., the rate at which aircraft are lost and do not return to the air base); a fixed number of attacks on the air base which determine when and how many resources are lost; and sortie demands placed on the air base (i.e., how many sorties the air base unit tries to fly).

The Experimental Design and Model

Sortie generation and air base attack results were determined using the TSAR and TSARINA models. The experiment was based on a fractional factorial design by Box and Behnken (1960) with 130 simulation runs required versus 19,683 for the full factorial. Twenty replications were also made for a total of 2600 simulation runs. Although the Box and Behnken design was to estimate a second degree graduating polynomial, the assumed model was stated as:

$$S_i = B_0(i) + \sum_{j=1}^{9} B_j(i) X_{1j} + e_i$$

where S_i = sorties flown on Day i

X_{1j} = level of resource j on Day 1

$B_j(i)$ = beta coefficient for jth resource on Day i

Regression was used to find a system of equations, one for each day, to predict the effect of changes in variable level.

Findings and Conclusions

One conclusion of the Folkeson (1986) study is that different factors or resources appear to be important at different times. Thus the resourcing decision depends on how long one expects the "war" to last. If one plans on 14 days, but then must operate over 30 days, the results may not be favorable because the "wrong" resources were invested in. For example, personnel seemed to have its biggest effect in the early days, while fuel (POL) contributed to sorties later in the war. Ideally these contributions must be balanced to ensure the highest level of sortie generation possible within budget constraints.

Problems With the Design

To estimate a model with only main effects, as was done, would require far fewer runs, and a two-level design, rather than three-level, could have been used. The same results should be obtained with only 32 runs (a 1/16 fractional replication of a 2^9 full factorial experiment). For the number of simulation runs and computer time involved in this experimental design, the inference space is extremely limited; they can only suggest results for a single air base under a single, very specific scenario. The experiment does not allow for an estimate of the impact of the attacks on sortie generation. It also makes no account for the randomness found in the TSARINA attacks; blocking is used to account for the randomness only in TSAR, but then is not included in the regression, thus ignoring any variance reduction gained by blocking. Finally, as recognized by the authors, interaction terms may be very significant and need to be included in the estimated model.

Statistically-Controlled Experimental Design

Much has been written concerning the design of experiments in order to achieve certain statistical characteristics. Steinberg and Hunter (1984) provide a review of this research area and include an extensive bibliography. We focus on a specific issue related to experimental design which is the development and use of variance reduction techniques (VRT).

Variance Reduction Techniques In Simulation

As discussed by Wilson (1984), the primary disadvantage of using simulation models, particularly those that model large-scale systems, to generate experimental data is the large number of often lengthy simulation runs required and the associated computing cost. Because of these high costs, various VRTs have been developed which attempt to reduce the number of runs needed to achieve the desired level of precision for the parameters to be estimated.

In general, simulation experimenters run their model some number of times to generate observations of the random variable Y, the response of interest. Following Wilson (1984), the simulation model is a response function $\psi(\cdot)$ with inputs $\{U_i: i \geq 1\}$ of independent random numbers. Assuming a finite upper bound m on the number of input variates sampled during one run of the model, the set of arguments for $\psi(\cdot)$ can be represented by an m x 1 random vector $\mathbf{U} = [U_1, \ldots, U_m]'$. Thus $Y = \psi(\mathbf{U})$ and $\theta = E(Y)$. From the sample, the sample mean $\bar{Y}_n$ is computed for the response Y over n independent replications of the simulation model. $\bar{Y}_n$ is an unbiased estimator of $E(Y) = \theta$, the population mean response, with $Var(\bar{Y}_n) = Var(Y)/n$. The desired result when using a VRT is to estimate $\hat{\theta}_n$ where $E(\hat{\theta}_n) = \theta$ and $Var(\hat{\theta}_n) < Var(\bar{Y}_n)$. Wilson (1984) further develops this discussion by including efficiency measures for evaluating VRTs.

Two categories of VRTs are delineated by Wilson (1984): correlation methods and importance methods. In this research we focus on correlation methods which use the linear correlation of the simulation responses to improve variance results. Even more specifically, we can focus on the use of random numbers which are integral cogs in the machinery of Monte Carlo simulations.

Random Number Assignment in Monte Carlo Simulation

How the random numbers are used in a simulation can be controlled to some extent by the experimenter. A single random number stream may be generated and used sequentially whenever random input variates are needed by the model. Another approach is to use different streams for individual components or processes within the model, thus linking randomness as determined by the random number stream more directly to a process. Schruben and Margolin (1978) provide an example of a hospital simulation which uses a set of six random number streams where each stream drives a particular stochastic component of the model. Whichever approach is used, a random number stream is usually generated from some starting value or seed which allows the stream to be reproduced and controlled by the experimenter. Thus the randomness of the simulation can be related to the beginning seed(s) as determined by the experimenter.

When planning the simulation experiment, the researcher must determine the random number streams to be used to generate each design point in the experiment. Schruben and Margolin (1978), Wilson (1984), and Brately et al. (1983) provide the basis for the following brief discussion of three assignment alternatives. Suppose we have a parameter Y^0 to be estimated. Let $Y_1 = \psi_1(U_1)$ and $Y_2 = \psi_2(U_2)$. There are three basic methods to approach the simulation experiment with respect to the use of the random number streams.

Independent streams is a method where different, randomly chosen streams are used at each design point. Typically, this approach results in uncorrelated samples. Here we simply make independent runs to obtain a single observation of Y^0.

Common random numbers is the approach where the same set of random number streams is used at two or more design points. Positive correlations between the design points are typically induced. Thus, if we are interested in estimating the difference $E(Y_1) - E(Y_2)$, this method could be used to reduce the variance of $Y^0 = Y_1 - Y_2$

$$Var(Y_1 - Y_2) = Var(Y_1) + Var(Y_2) - 2\ Cov(Y_1, Y_2)$$

by inducing $Cov(Y_1, Y_2) > 0$.

Antithetic variates is a third assignment method where a seed vector is used at one design point, and then each random number is subtracted from unity, creating a "new" stream which is used at a second design point. Thus if random number stream $R = (r_1, r_2, \ldots)$, then the antithetic stream $\bar{R} = (1 - r_1, 1 - r_2, \ldots)$. This method tends to induce a negative correlation between the samples. For example, suppose we wanted to estimate $E(Y_1)$ where Y_1, Y_2 represent replicates so that $\psi_1 = \psi_2$. This method could be used to reduce the variance of $Y^0 = \frac{1}{2}(Y_1 + Y_2)$

$$\begin{aligned} Var[\tfrac{1}{2}(Y_1+Y_2)] &= \frac{1}{4} Var(Y_1) + \frac{1}{4} Var(Y_2) + \frac{1}{2} Cov(Y_1,Y_2) \\ &= \frac{1}{2} Var(Y_1) + \frac{1}{2} Cov(Y_1,Y_2) \end{aligned}$$

by inducing $Cov(Y_1,Y_2) < 0$.

We should note also that these techniques of random number assignment do not guarantee variance reduction. Successful application depends on the structure of the model and the particular problem (Wilson, 1984).

CHAPTER III - METHODOLOGY

An F-15 aircraft data base currently being used by the RAND Corporation and various Air Force agencies is simulated using the TSAR/TSARINA models. The goal is to identify key resource factors and significant two-way interactions and explore the nature of the relationship between the independent variables and the response variable. First we discuss the factors to be modeled; each is described along with its relationship to sortie generation and the resource levels used in the experiment. Next we examine the metamodels to be estimated and the assumptions of each. Then the experimental design is explained. The final section discusses how the research objectives listed in Chapter I will be assessed.

The Resource Factors

Nine resource factors are included as variables in this research. These were selected based on previous research and experimentation with the TSAR model and have shown to be important factors in the sortie generation process. Figure 3.1 depicts the relationship of these factors to others in the TSAR and TSARINA F-15 data bases. Since a two-level experimental design is used, each factor is evaluated at a

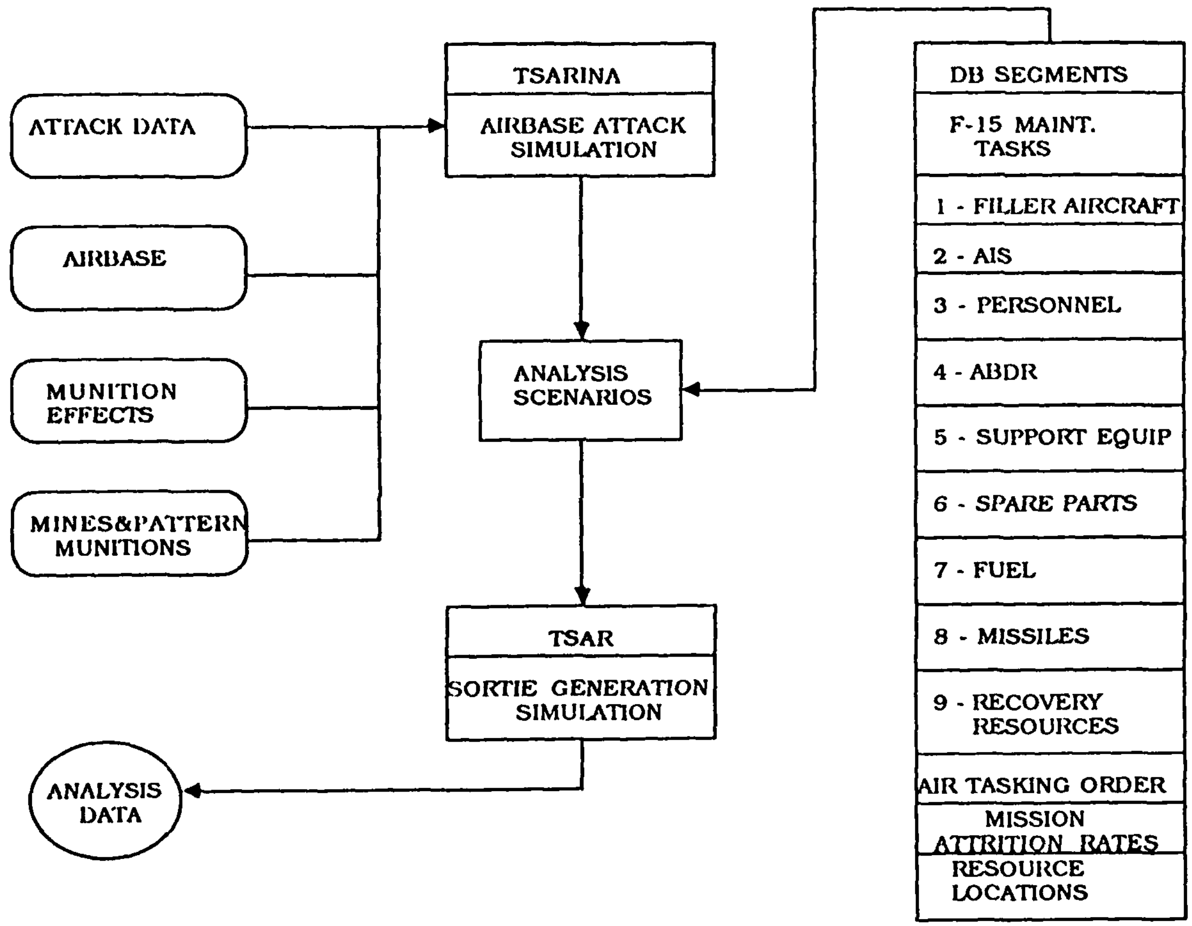


Figure 3.1

TSAR/TSARINA Database Factors

"high", or more favorable, level and a "low", or less favorable, level.

To be realistic and useful, the derived metamodel must capture a wide spectrum of various logistics resource positions as well as elements of an uncertain wartime environment such as air base attack and attrition. Thus the high and low levels for each variable are chosen so that we have a valid and realistic inference space. The high levels represent the logistics infrastructure one would expect to find supporting 72 F-15 aircraft. In an era of tight defense budgets, it is very unlikely we would find one with greater resources. Given the "high", it seems logical to then degrade it to develop the "low" level for each resource. The inference space thus enclosed should be realistic for most situations encountered by decision makers when forecasting with a simpler, derived metamodel.

Each factor also represents an actual functional area found within the logistics infrastructure of a tactical air base. Each factor is described below regarding its high level, low level, and general impact on sortie generation. Tables 3.1 and 3.2 below summarize the high and low levels of the resources respectively.

Factor B: Filler or Replacement Aircraft

Seventy-two fighter aircraft are normally assigned to a tactical air base with three squadrons. Each of these flying

Table 3.1

High Levels for the Resource Factors

FACTOR	HIGH LEVEL
B - Aircraft	72 assigned plus 18 filler aircraft available with 72 hour delay
C - ABDR Capability	6 assessors (2 per AMU) where work cannot begin until damage is inspected by a trained assessor
D - Recovery	Full range of improved procedures which includes manual workarounds; CE and EOD personnel and equipment also included
E - Personnel	Typical quantities expected -- assume these are the number authorized by specialty
F - AIS	2 sets with 5 stations each
G - Support Equip	Typical quantities expected -- assume these are number authorized
H - Spares	Computed by TSAR with 100% safety factor using AFM 67-1 Chap 11 procedures
J - Missiles	Initial Stocks - 300 AIM9-M 300 AIM7-M 612 AIM9-M components 424 AIM7-M components Day 1 - delivery of AIM-9Ms & AIM-7Ms Days 2,5,10,15 - deliveries of AIM-9M and AIM-7M components
K - Fuel	Deliveries arrive Days 10,15,20,25

Table 3.2

Low Levels for the Resource Factors

FACTOR	LOW LEVEL (A DEGRADATION OF HIGH CASE)
B - Aircraft	72 assigned with no filler aircraft available
C - ABDR Capability	3 assessors (1 per AMU) where work cannot begin until damage is inspected by a trained assessor
D - Recovery	Slower alternate procedures; CE and EOD personnel and equipment reduced to 75% of high level
E - Personnel	Quantities reduced to 75% of high level
F - AIS	1 set with 5 stations
G - Support Equip	Quantities reduced to 75% of high level
H - Spares	Computed by TSAR with 10% safety factor using AFM 67-1 Chap 11 procedures
J - Missiles	Initial Stocks - same as high case Days 5,10,15 - deliveries of AIM-9M and AIM-7M components
K - Fuel	Deliveries arrive Days 10 and 20

squadrons is supported by an Aircraft Maintenance Unit or AMU in addition to centralized repair shops. During wartime, filler or replacement aircraft may be available to offset the loss of aircraft due to attrition and air base attacks. As a general rule, the logistics infrastructure is designed to support no more than seventy-two aircraft at any time. When a loss occurs, a replacement is requested. If available, the filler arrives after a period of delay.

High Level: Seventy-two aircraft are assigned to the base with an additional 18 filler or replacement aircraft available, each with a 72-hour delay.

Low Level: Seventy-two aircraft are assigned, but no filler aircraft are available.

Impact: More aircraft available increases the potential to fly more sorties by keeping the air base closer to its full complement of aircraft.

Factor C: Aircraft Battle Damage Repair (ABDR) Capability

ABDR is the specialized repair of aircraft that return to the air base with damage caused by enemy ground artillery, antiaircraft weapons, or air-to-air combat. The nature of the damage requires the use of special techniques and materials. Highly trained assessors must plan and direct the repair actions. Thus, the number of assessors limits the amount of ABDR that can be accomplished at any given time.

High Level: Six assessors (2 per AMU) are available. Repair work cannot begin until a damaged aircraft has been inspected by a trained assessor.

Low Level: Only three assessors (1 per AMU) are available.

Impact: An increase in the number of assessors decreases the number of battle-damaged aircraft waiting to begin repairs. As a result, ABDR capability increases, and more aircraft are available sooner for flying sorties.

Factor D: Recovery From Air Base Attack

"Recovery" centers on the repair of damaged runways and taxiways so that flying can resume. EOD or Explosive Ordnance Disposal personnel must first clear unexploded munitions dropped by the attackers from areas in the vicinity of damaged pavement. Then holes in the pavement must be filled, rubble removed, and pavement poured by Civil Engineering (CE) personnel. When a minimum size take-off and landing surface is available and accessible to the aircraft, flying operations can resume.

High Level: A full range of procedures is simulated including manual workarounds. Also included are full authorizations of civil engineering and ordnance disposal personnel and equipment necessary to support the size of the air base.

Low Level: Slower alternate procedures are used instead of the normal methods. CE and EOD personnel and equipment levels are also reduced to 75% of the "high" level.

Impact: Higher recovery capability results in runways and taxiways being opened sooner and thus leads to more sorties.

Factor E: Maintenance Personnel

Maintenance technicians typically are trained to repair and maintain specific aircraft systems. For example, there are jet engine specialists, navigation systems specialists, etc., as well as generalists like crew chiefs who are responsible for the overall condition and servicing of the aircraft. The number of crew chiefs and each type of specialist assigned to the air base is determined by the number of aircraft to be supported. Thus certain manpower levels are determined and "authorized" to support seventy-two aircraft.

High Level: Here we have the "typical" number expected by specialty. This accounts for the fact that full authorizations are often not reached due to personnel shortages and long training pipelines.

Low Level: Quantities of each specialist are reduced to 75% of the "high" level.

Impact: More maintenance people allow more aircraft to be worked at any point in time, thus leading to quicker repairs and more flying.

Factor F: Avionics Intermediate Test Station (AIS)

The avionics on the F-15 aircraft are very sophisticated and require special diagnostic equipment (i.e., the AIS) for their repair. Ideally the malfunctioning "black boxes" are removed and replaced with a spare or extra working component. However, at some point the broken ones must be repaired and this requires the AIS equipment. Further complicating the process is the fact that the AIS itself is highly susceptible to failure and requires repair of its own components.

High Level: Two AIS sets, each consisting of 5 stations, are available to repair the avionics "black boxes."

Low Level: Only one set with 5 stations is available.

Impact: The availability of two sets increases the likelihood that avionics components can be repaired and made available to fix aircraft which can then fly.

Factor G: Support Equipment

Support equipment include all the equipment necessary to repair an aircraft and/or prepare it for flying. Examples include fuel trucks, tow tractors, power carts, missile trailers, maintenance stands, etc. Like personnel, certain quantities of each type are "authorized" based on the number of aircraft assigned to the air base.

High Level: Quantities are the expected number of each type of equipment typically available. Due to budget shortages and procurement pipelines, full authorization levels are often not realized.

Low Level: Quantities are reduced to 75% of "high" level.

Impact: When more equipment is available, more aircraft can be worked on at any point in time, and thus the repair time is shortened and more aircraft are available for flying.

Factor H: Spare Parts

Spare parts are used to replace damaged or defective parts on the aircraft and its systems, support equipment, and the AIS. The type and number of parts stocked typically depend on the number of aircraft assigned and the expected number of sorties to be flown.

High Level: Stockage levels by type are computed by the TSAR model with a 100% safety factor based on AFM 67-1 Chapter 11 procedures.

Low Level: Levels are computed with a 10% safety factor.

Impact: With spares available, defective parts can be removed and replaced with good parts and the aircraft is ready to fly. The defective part is repaired later and becomes a spare. However, when no spare is available, the defective part must be removed, repaired in the appropriate shop, and then returned to the aircraft. Thus, more spare parts leads to faster repairs and more aircraft available for flying.

Factor J: Missiles

Missiles are the primary munition of the F-15; without missiles these aircraft cannot fly effective missions. Thus aircraft will not take off without missiles in this simulation. Two types of missiles are available and are assembled from component parts by munitions specialists.

High Level: Initial stocks of built-up missiles are available as well as component parts to build more. Additional missiles are delivered on Day 1. Additional components are delivered on Days 2, 5, 10, and 15.

Low Level: The same initial stocks as in the "high" case are available. The delivery schedule is also the same, but no deliveries are received on Days 1 and 2. Here we project that deliveries may not arrive due to enemy attack and/or sabotage.

Impact: More missiles available means more sorties can potentially be flown, i.e., there is less chance that a sortie will not be flown because of a missile shortage.

Factor K: Fuel

Aircraft must be refueled before each flight. Fuel is delivered and pumped by a special vehicle or can be pumped from a fixed refueling point. Storage tanks and delivery vehicles are susceptible to sabotage and air base attacks.

High Level: Initial stocks are on-hand plus deliveries arrive on Days 10, 15, 20, and 25.

Low level: The same initial stocks are available and the delivery schedule is the same. However, no deliveries arrive on Days 15 and 25.

Impact: Aircraft cannot fly without fuel. More fuel available lessens the chance of a sortie not flown because of fuel shortages.

The Environmental Factors

This research also includes two environmental factors, where we define the environment to be the hostile arena in which sorties are to be flown. Such factors are not within the managerial control of the air base leaders and decision-makers. Rather, the factors must be reacted to. Here, the environmental factors we model as variables are attacks upon the air base and the attrition inflicted upon our own aircraft while flying sorties. A third, locally uncontrollable factor is the amount of flying the unit is tasked to fly. Each factor is described below and is shown in Figure 3.1 as it relates to the other factors included in the TSAR and TSARINA models.

Air Base Attacks

Enemy attacks on the air base destroy resources, create damage which inhibits or stops flying operations, and, in general, disrupt normal operations. When and how many times an air base will be attacked is unknown; however, due to the effectiveness of attacks in disrupting sortie generation, they must be expected. Generally, as time passes, the enemy's ability to deliver an attack is expected to decrease.

We use the TSARINA model to simulate attacks on the air base. Conventional (i.e., nonnuclear and nonchemical) attacks by enemy aircraft are assumed which focus on runways, taxiways, and aircraft shelters. This type of attack can be quite effective in preventing sorties from being flown. The attacks are optimized from the enemy's perspective with regard to aimpoints and time of attack. Six attacks occur in the first five days and are summarized in Table 3.3.

Attrition of Our Aircraft

Every time a sortie is flown, the aircraft is exposed to various risks which may result in its loss. Risks include mechanical malfunctions, acts of nature, enemy ground fire or air-to-air attack, etc. These risks are expressed as a loss rate per sortie flown. Attrition factors are modeled within TSAR either based on time periods or on the number of friendly sorties flown. The high and low levels are described below.

Table 3.3

Summary of the Air Base Attacks

DAY	TIME	NUMBER OF ATTACKERS	MUNITIONS	TARGET
1	0550 hours	10 bombers	24 bombs each	runways/taxiways
		5 bombers	24 mines each	"
	1450	8 fighter-bombers	10 bombs each	runways/taxiways
		4 fighter-bombers	10 mines each	"
		24 fighter-bombers	1 bomb each	aircraft shelters
2	0550	8 fighter-bombers	10 bombs each	runways/taxiways
		4 fighter-bombers	10 mines each	"
		24 fighter-bombers	1 bomb each	aircraft shelters
3	0550	4 bombers	24 bombs each	runways/taxiways
		1 bomber	24 mines	"
		10 bombers	24 bombs each	support facilities and shelters
4	0550	4 bombers	24 bombs each	runways/taxiways
		1 bomber	24 mines	"
		10 bombers	24 bombs each	support facilities and shelters
5	0550	4 fighter-bombers	10 bombs each	runways/taxiways
		4 fighter-bombers	10 bombs each	support facilities and shelters

High Level. The high or more favorable level of attrition is modeled as a stepwise reduction of the attrition rate from 1.2% to 1.0% of sorties flown. The timing of the reduction is based on the number of sorties flown by our aircraft. The attrition rate starts at 1.2% and drops to 1.1% when we have flown a total of 166 sorties. When the cumulative number of sorties flown reaches 327, the attrition rate further declines to 1.0% where it remains for the rest of the 30-day period. The logic behind the reduction is that the more we fly, the less effective the enemy is against us, and thus the attrition rate is driven down. If we cannot fly many sorties, the enemy maintains a higher level of effectiveness against our aircraft. Thus, the more we can fly, the faster our attrition rate declines.

Low Level. The low or less favorable level of attrition is a constant 1.2% per sortie. Here our sorties have no effect on the effectiveness of the enemy against our aircraft.

Air Tasking Orders (ATO)

Each air base is tasked to fly during wartime by a central agency. These taskings will generally exceed the rates flown in peacetime. In this research we have assumed that the taskings will be high and will, in general, exceed the capability of the air base. This, in effect, creates a "fly as much as you can" scenario where we can focus on the logistics capabilities of the air base. Over time, the level of tasking decreases, but is still higher than peacetime rates. This factor is treated as a constant in all simulation runs.

The Metamodels to be Estimated

The goal of our analyses is to derive a useful and realistic metamodel which captures the key main effects and any significant two-way interactions between the main factors. Higher order interactions are assumed to be neglible. Additionally we want to evaluate the dynamic influences of significant factors and interactions over time, with and without attacks on the air base. We will first discuss the metamodel for the case where there are no attacks and then the case where attacks are present.

The Metamodel for the Case of No Attacks

The metamodel for each day's flying performance is assumed to be linear and comprised of the nine main resource effects plus the environmental variable (i.e., our attrition) as well as two-way interaction terms. The daily model is of the following form:

$$S_i = \beta_0(i) + \sum_{j=1}^{10} \beta_j(i) X_{1j}$$

$$+ \sum_{j=1}^{9} \sum_{k=j+1}^{10} \beta_{jk}(i) X_{1j} X_{1k} + \varepsilon(i) \qquad (3.1)$$

where S_i = the number of sorties flown on Day i

X_{1j} = level of factor j on Day 1, and

$\varepsilon(i)$ reflects the variability due to the randomness within the logistics processes and attrition in addition to the experimental error, where $\varepsilon(i) \sim N(0,\sigma_\varepsilon^2)$.

The Attack Case Metamodel

When the air base is attacked, we have in effect an eleventh factor which influences the sortie generation process. The model to be estimated is the same except now the error term contains variability due not only to the logistics processes and attrition, but also the variability due to the attacks. The model is:

$$S_1^* = \beta_0^*(i) + \sum_{j=1}^{10} \beta_j^*(i) X_{1j} + \sum_{j=1}^{9} \sum_{k=j+1}^{10} \beta_{jk}^*(i) X_{1j} X_{1k} + \varepsilon^*(i) \qquad (3.2)$$

where S_i^* = the number of sorties flown on Day i

X_{1j} = level of factor j on Day 1, and

$\varepsilon^*(i)$ reflects the variability due to the randomness within the logistics processes and attrition plus the variability due to the air base attacks in addition to the experimental error, where $\varepsilon^*(i) \sim N(0,\sigma_{\varepsilon^*}^2)$.

Although the form of the metamodel is the same for both cases, the beta coefficients are not assumed to be the same. In fact, imbedded in $\beta_0^*(i)$ is the mean effect of the attacks as well as the mean effect of the factor levels. We also expect the variability to be greater in the attack case than in the no-attack case.

The Experimental Design

The experimental design needs to isolate each main effect and two-way interaction so that the significance of each can be determined. A Resolution V design is required so that no main effects or two-way interactions are confounded with one another. A full factorial design requires 2^{10} or 1024 separate simulation runs for each case (i.e., attack and no-attack) for a total of 2048 runs. However, since we are assuming three-way and higher order interactions to be negligible, we can and should use a fractional factorial design. From McLean and Anderson (1984), we selected a 1/8 replication of a 10 factor design (nine resources plus attrition of our aircraft) at two levels each (Figure 3.2). This design requires 128 treatment combinations.

We also want to estimate the impact of air base attacks on sortie generation so this effect must be isolated if possible. Our approach is to perform the experiment without attack, and then repeat it with attacks included. The results then can be compared; since the factor treatments in

FACTOR

A = attrition	F = Avionics Intermediate Test Station (AIS)
B = filler aircraft	G = support equipment
C = Aircraft Battle Damage Repair (ABDR) capability	H = spare parts
D = recovery resources	J = missiles
E = personnel	K = fuel

DEFINING RELATION I = ABEGHJ = ACFGJK = BCEFHK
= ABCDK = CDEGHJK = BDFGJ = ADEFH

lower case letter means factor at high level; (1) = all factors low

Block 1	Block 2	Block 3	Block 4	Block 5	Block 6	Block 7	Block 8
(1)	bcdegjk	abdfhjk	acefgh	aegjk	abcd	bdefgh	cfhjk
bdfj	cefgk	ahk	abcdeghj	abdefgk	acfj	eghj	bcdhk
beghk	cdhj	adefgj	abcfk	abhj	acdeghk	dfk	bcefgj
defghjk	befh	abeg	acdjk	adfh	abcefghjk	bjk	cdeg
abchjk	adegh	cdf	befgjk	bcegh	dhjk	acdefgjk	abf
acdfhk	abefghj	bcj	degk	cdefghj	bfhk	abcegk	adj
acegj	abdk	bcdefghk	fhj	ck	bdegj	abcdfhj	aefghk
abcdefg	afjk	ceghjk	bdh	bcdfjk	efg	ach	abdeghjk
bcfghj	defhk	acdgk	abej	abcefhk	adfghj	cdej	bgk
cdgh	behjk	abcfgjk	adef	acdehjk	abgh	bcef	dfgjk
cefjk	bdfg	abcdeh	aghjk	acfg	abdefjk	bcdghjk	eh
bcdek	gj	acefhj	abdfghk	abcdgj	aek	cfghk	bdefhj
afgk	abcdefj	bdghj	cehk	efj	bcdfgk	abdehk	acghj
abdgjk	ace	fgh	bcdefhjk	bde	cgjk	aefhjk	abcdfgh
abefh	acdfghjk	dejk	bcg	bfghjk	cdefh	adg	abcejk
adehj	abcghk	befk	cdfgj	dghk	bcehj	abfgj	acdefk

ANOVA TABLE

SOURCE	df
Main Effects	10
Two-way Interactions	45
Blocks	7
Residual	65
TOTAL	127

BLOCK CONTRASTS:

	1	2	3	4	5	6	7	8
ABEF	0	0	1	1	0	0	1	1
ACDEJK	0	1	0	1	0	1	0	1
BCDFJK	0	1	1	0	0	1	1	0
BGHJK	0	0	0	0	1	1	1	1
AEFGHJK	0	0	1	1	1	1	0	0
ABCDEGH	0	1	0	1	1	0	1	0
CDFGH	0	1	1	0	1	0	0	1

Figure 3.2

The Experimental Design

each sub-experiment are the same, we should be able to isolate the effects of the air base attacks. This approach results in a total of 256 separate simulation runs, 128 for each case, of thirty days each. We should note here that this approach restricts randomization since a treatment (i.e., factor levels) is input to TSAR and run for 30 consecutive days. This makes the daily runs correlated for each treatment. The alternative, running each day independently within each treatment, would require 7680 runs which is prohibitive.

Randomness in the logistics processes in TSAR and the sensitivities of results due to randomness of TSARINA attacks led us to use a blocking scheme to reduce the variance as well as to help ensure that the results did not depend on a single scenario. Randomness is a key component of simulation models and the results are often related to the streams of random numbers used in the model. By blocking based on random numbers, we can usually reduce the experimental error as compared to a completely randomized design.

A major consideration is the number of blocks to use in the experimental design. The choice involves tradeoffs, especially in our interest in reducing variance as well as in capturing a representative sample space. On one hand, no blocking allows the widest possible inference space with a different random version of an attack for each treatment combination. However, this does not help to reduce variance as there is no common thread between the runs in terms of random numbers. On the other extreme, one block allows the greatest amount of commonality because all treatments use exactly the same attack. However, this restricts the inference space since we have only a specific attack based on a single, specific stream of random numbers. Previous research uses both extremes where Folkeson et al. (1986) use a single attack for all resource combinations and Folkeson (1988) replicates a design point with thirty random versions of an attack. Due to the size of our experiment, this latter approach is not practical in terms of computer run times. Thus we sought an approach that would yield variance reduction through blocking and still have a representative inference space that accounts for randomness in the attacks. As a result of these tradeoffs we selected a design with 8 blocks.

In the no-attack case, each block is defined by a different starting seed (randomly selected) for the TSAR random number stream. The random numbers for all random events are drawn from this stream. Most of the random events in TSAR concern the operation of the aircraft, i.e., which systems and components on the aircraft malfunction and need to be repaired. The flow of random numbers is not congruent from run to run because malfunctions cause additional random numbers to be used. For example, in one run random number A may determine whether the engine on Aircraft #1 requires maintenance; if so, random number B will be used to determine what component on the engine failed. Suppose random number A had indicated that the engine on Aircraft #1 required no maintenance. Then random number B will be used to either check another system or another aircraft. With 72 aircraft and 81 systems/subsystems which can malfunction, it is easy to see that the the random number usage is not going to be congruent from one run to another. Other random numbers are used to determine which aircraft are attrited by the enemy and the time to repair battle-damaged aircraft. Although we have this obvious incongruency run to run, each block's results do have a common starting point in the form of the starting random seed, and thus we can determine the blocking effect for each daily model. Because of the incongruent use of random numbers in TSAR, we do not expect a large blocking effect.

In the attack case, each block has the same attack in terms of targets and number of attacking aircraft, but each has a different randomly selected starting seed within the TSARINA model. This gives us eight different random variations of the same attack. Random numbers are used to allow for randomness in the results of the <u>intended</u> attack. For example, each attacking aircraft has a Desired Mean Point of Impact (DMPI) which is where the pilot wants the bomb(s) to land. However the model allows for dispersion around each DMPI to be determined by random numbers. Hence bombs may land short, long, left, or right of the DMPI. Further, the ballistic dispersion and the reliability of each bomb is determined by random numbers from the stream. As a result, each attack is going to be different based on the starting seed for the TSARINA random number stream. The use of random numbers in TSARINA would be congruent case to case except that a probability of arrival is also randomly checked for each attacker. If an attacker is attrited, the model does not check its bombs for impact point and reliability. TSAR seeds are also repeated for each block so that the only major difference between comparable blocks in the two sub-experiments is the attack. Figure 3.3 depicts the blocking scheme used with regard to random number streams. With the inclusion of blocking, we need to restate the metamodels to be estimated.

The Revised Metamodels (With Blocking)

With blocking in our experimental design, we need to add another factor to each metamodel that captures the effect of the various random number streams in the TSAR and TSARINA models. The intent is to explicitly account for variability due to the block effects described above and thereby reduce experimental error and make the experiment more powerful.

The Metamodel for the No Attack Case

$$S_i = \beta_0(i) + \sum_{j=1}^{10} \beta_j(i) X_{1j} + \sum_{j=1}^{9} \sum_{k=j+1}^{10} \beta_{jk}(i) X_{1j} X_{1k}$$

TREATMENTS	NO-ATTACK CASE	ATTACK CASE
TREATMENT 1 . . . 16	{TSAR SEED 1}	{TSAR SEED 1 TSARINA SEED 1}
TREATMENT 17 . . . 32	{TSAR SEED 2}	{TSAR SEED 2 TSARINA SEED 2}
• • •	• • •	• • •
TREATMENT 113 . . . 128	{TSAR SEED 8}	{TSAR SEED 8 TSARINA SEED 8}

Figure 3.3

The Blocking Scheme

$$+ B_{11}(i) + \varepsilon(i) \tag{3.3}$$

where S_i = the number of sorties flown on Day i

X_{1j} = level of factor j on Day 1

$B_{11}(i)$ reflects the random effect on Day i due to

the random number streams in TSAR, where $B_{11}(i) \sim N(0,\sigma_B^2)$

$\varepsilon(i)$ reflects the experimental error, where $\varepsilon(i) \sim N(0,\sigma_\varepsilon^2)$

<u>The Attack Case Metamodel</u>

$$S_i^* = \beta_0^*(i) + \sum_{j=1}^{10} \beta_j^*(i) X_{1j} + \sum_{j=1}^{9} \sum_{k=j+1}^{10} \beta_{jk}^*(i) X_{1j} X_{1k}$$
$$+ B_{11}^*(i) + \varepsilon^*(i) \tag{3.4}$$

where S_i^* = the number of sorties flown on Day i

X_{1j} = level of factor j on Day 1

$B_{11}^*(i)$ reflects the random effect on Day i due to

random number streams in TSAR and TSARINA, where $B_{11}^*(i) \sim N(0,\sigma_{B*}^2)$

$\varepsilon^*(i)$ reflects the experimental error, where $\varepsilon^*(i) \sim N(0,\sigma_{\varepsilon*}^2)$

Assessing the Research Objectives

Four research objectives are identified above which are the focus of this work. Below we discuss how we measure the accomplishment of each objective.

The Effectiveness of the Experimental Design

A major objective of this research is to apply an experimental design that reduces the number of runs as much as possible while achieving acceptable levels of experimental error. To assess the extent to which this objective has been achieved, we estimate the effectiveness of the blocking scheme in terms of design efficiency and variance reduction.

Relative efficiency of blocking, compared to complete randomization is defined by Neter et al. (1985) as:

$$E = \frac{\sigma_r^2(\text{completely randomized design})}{\sigma_b^2(\text{randomized block design})}$$

The $MS_\varepsilon = SS_\varepsilon/df_\varepsilon$ for the randomized block design is an unbiased estimator of σ_b^2 (Neter et al., 1985). Further, an unbiased estimator of σ_r^2 is obtained by pooling the blocks and error components:

$$\hat{\sigma}_r^2 = \frac{\sum_{i=1}^{7} SS(B_{ij}) + SS_\varepsilon}{df_B + df_\varepsilon}$$

Thus we have relative efficiency

$$E = \frac{\left[\sum_{j=1}^{7} SS(B_{ij}) + SS_{\varepsilon}\right] / \left[7 + df_{\varepsilon}\right]}{SS_{\varepsilon} / df_{\varepsilon}} \tag{3.5}$$

This measure of relative efficiency indicates how much replication must be done with a completely randomized design to achieve the same precision in the variance of significant factors as obtained with the blocking design.

Percent variance reduction follows from the definition of efficiency. Thus,

$$\%\text{ variance reduction} = \frac{100\ [\text{old variance} - \text{new variance}]}{[\text{old variance}]}$$

$$= 100\ \frac{[\hat{\sigma}_r^2 - \hat{\sigma}_b^2]}{\hat{\sigma}_r^2}$$

$$= 100\ \frac{\left[\dfrac{\left(\sum_{j=1}^{7} SS(B_{ij}) + SS_{\varepsilon}\right)}{(df_B + df_{\varepsilon})} - \dfrac{SS_{\varepsilon}}{df_{\varepsilon}}\right]}{\dfrac{\left(\sum_{j=1}^{7} SS(B_{ij}) + SS_{\varepsilon}\right)}{(df_B + df_{\varepsilon})}} \tag{3.6}$$

Estimating the Daily Metamodels

Another major goal of this research is to estimate simpler metamodels from the detailed TSAR and TSARINA simulation models. Based on the above experimental design, we have a total of 3840 observations for each case (attack and no-attack). In other words, we have 128 responses for each day, one for each treatment or resource combination found in the design. Before deriving metamodels from these data, we first test whether the populations of the response variable are normally distributed. Next, based on the output data, we estimate the daily metamodels, and then evaluate their fit. Lastly, we compute confidence intervals for the population mean at certain design points.

Using the Shapiro-Wilk test for normality, we examine each case, attack and no-attack, to determine whether the response variable, sorties flown, follows a normal distribution. The number of sorties flown on each day for each design point has its own population characteristics; we therefore cannot combine the 128 daily sample data to test for normality. However, we can test for the normality of the population of responses at a specific design point. Normality can be tested at several design points and then we can possibly infer the same results for the remaining design points. Here we will select two design points, (a) all factors high and (b) all factors low, and run 20 independent replications for each case (i.e., with and without attacks) for sorties flown on Days $i = 1,5,30$. These two design points ought to represent the upper and lower bounds, respectively, of our inference space.

For design point (a), let S_{ij} denote the number of sorties flown on the i^{th} day of the j^{th} independent replication, $1 \leq i \leq 30$, $1 \leq j \leq 20$. Similarly define S_{ij} for the point (b). Then we apply the Shapiro-Wilk normality test (Anderson and McLean, 1974) first to the data set

$$\{S_{1j}^{(a)} \; : \; j = 1, \ldots, 20\}$$

then to the data set

$$\{S_{5j}^{(a)} \; : \; j = 1, \ldots, 20\}$$

and then to the data set

$$\{S_{30j}^{(a)} \; : \; j = 1, \ldots, 20\}.$$

Similarly we test $S_{ij}^{(b)}$ for normality on Days i = 1, 5, 30. This gives 6 Shapiro-Wilk test statistics

$$W_i^{(k)} \text{ for } k = a, b; \quad i = 1, 5, 30.$$

If α is the overall level of significance for the normality test, then we accept the null hypothesis of normally distributed daily sortie counts if

$$W_i^{(k)} \; > \; W^*_{\alpha/6} \quad \text{for } i = 1, 5, 30; \quad k = a, b$$

where $W^*_{\alpha/6}$ is the quantile of order $\alpha/6$ for the Shapiro-Wilk distribution for sample size 20. Thus if $\alpha = 0.06$,

$$W^*_{\alpha/6} \; = \; W^*_{0.01} \; (n=20) \; = 0.868$$

from page 405 of Anderson and McLean (1974).

<u>To derive the daily metamodels</u>, we use stepwise backward regression until all remaining factors are significant at the

0.10 level. The blocking variables, B1 through B7, are always included in the model regardless of their level of significance. The resulting metamodel for each day identifies the factors which best predict the level of sorties flown for that day given the level of significance for retaining a variable in the model.

To evaluate the metamodels, we examine each daily model with regard to the coefficient of multiple determination (R^2) to see how well the independent variables in the reduced model explain the variation in sorties.

Confidence intervals are next estimated for the population mean of specific design points.

A 100(1-α)% confidence interval on $\mu_k(i)$, the mean number of sorties flown on Day i for the k^{th} design point of the no-attack case, is

$$x_k\hat{\beta}(i) \pm t_{1-\alpha/2}(DF_{\varepsilon(i)}) \cdot \sqrt{MS_{\varepsilon(i)} x_k (X'X)^{-1} x_k'} \qquad (3.7)$$

Similarly, a 100(1-α)% confidence interval on the comparable quantity $\mu_k^*(i)$ for the attack case is

$$x_k\hat{\beta}^*(i) \pm t_{1-\alpha/2}(DF_{\varepsilon^*(i)}) \cdot \sqrt{MS_{\varepsilon^*(i)} x_k (X'X)^{-1} x_k'} \qquad (3.8)$$

Homogeneity of Variance. Since $MS_{\varepsilon*(i)}$ and $MS_{\varepsilon(i)}$ are correlated due to common random numbers, we cannot claim that $MS_{\varepsilon*(i)}/MS_{\varepsilon(i)}$ has an F-distribution in order to compare the variances of the two cases. However, we can compute sample variances based on the 20 independent replications we made at various design points for each case. Thus for the no-attack case we have sorties flown

$$S_{ij}^{(k)} : 1 \le j \le 20 \text{ for Day } i = 1,5,30$$
$$\text{and design point } k = a,b$$

and we can estimate the population variance

$$\hat{\sigma}_{ik}^{2} = \frac{1}{19} \sum_{j=1}^{20} [S_{ij}^{(k)} - \bar{S}_{i}^{(k)}]^{2} \text{ for Day } i = 1,5,30$$
$$\text{and design point } k = a,b$$

Similarly for the attack case we have

$$S_{ij}^{*(k)} : 1 \le j \le 20 \text{ for Day } i = 1,5,30$$
$$\text{and design point } k = a,b,$$

and we can estimate the population variance

$$\sigma_{ik}^{*2} = \frac{1}{19} \sum_{j=1}^{20} [S_{ij}^{*(k)} - \bar{S}_{i}^{*(k)}]^{2} \text{ for Day } i = 1,5,30$$
$$\text{and design point } k = a,b.$$

From these data, we can test for homogeneity of variance a) within each case and b) between cases. When testing <u>within</u> cases, we compare results for design point (a) to results for design point (b) for each Day i = 1,5,30. When testing between cases, we compare results for design point (k) in the no-attack case to the results for the same design point (k) in the attack case for each Day i = 1,5,30. These tests are further defined below.

For testing homogeneity of variance within each case, we have the following for each Day i = 1,5,30 of the no-attack case:

Hypotheses: $H_0: \sigma_{ia}^2 = \sigma_{ib}^2$

$H_1: \sigma_{ia}^2 \neq \sigma_{ib}^2$

Test Statistic: $F = \hat{\sigma}_{ia}^2 / \hat{\sigma}_{ib}^2$

Decision: Reject H_0 if $F \geq F(\alpha/2, n_1-1, n_2-1)$, i.e., with $n_a = n_b = 20$ and $\alpha = .05$ reject H_0 if $F \geq 2.545$.

The same test is performed for the attack case where σ_{ia}^{*2} replaces σ_{ia}^2 and σ_{ib}^{*2} replaces σ_{ib}^2.

For testing homogeneity of variance between the cases, we have the following for each design point k = a,b and Day i = 1,5,30:

Hypotheses: $H_0: \sigma_{ik}^{*2} = \sigma_{ik}^2$

$H_1: \sigma_{ik}^{*2} \neq \sigma_{ik}^2$

Test Statistic: $F = \hat{\sigma}_{ik}^{*2} / \hat{\sigma}_{ik}^2$

Decision: Reject H_0 if $F \geq 2.545$.

Evaluating the Impact of Attacks

A third research objective is to determine if attacks on the air base cause a significant difference in flying performance. To evaluate this, we would like to use a pairwise comparison of the attack and no-attack cases by treatment and by day. Thus we would have 128 differences (one for each design point) for each day,

$$D_j = S_{1j} - S_{2j} \qquad j = 1,2,\ldots,n$$

where S_{1j} is the number of sorties flown with jth treatment in the no-attack case and S_{2j} is the number of sorties flown with jth treatment in the with attack case. However, the $\{D_j: \ 1 \leq j \leq n\}$ are not independent since the design uses common random numbers across all n design points; moreover they are not identically distributed because they come from different design points. Thus a different approach is necessary.

At the k^{th} design point, let $X_{1j}(k)$ denote the corresponding level of the j^{th} factor on day 1; and let

$$\underset{\sim}{x}_k \equiv [1 \; X_{1,1}(k) \; \ldots \; X_{1,10}(k) \; X_{1,1}(k).X_{1,2}(k)$$
$$\ldots \; X_{1,9}(k).X_{1,10}(k)]$$

$$1 + 10 + \frac{9(10)}{2} = 56 \text{ terms} \tag{3.9}$$

denote the overall vector of factor levels so that the no-attack metamodel can be written

$$E[S_i] = \underset{\sim}{x}_k \underset{\sim}{\beta}(i) \tag{3.10}$$

where $\underset{\sim}{\beta}(i) \equiv [\beta_0(i)\ \beta_1(i) \ldots \beta_{10}(i)\ \beta_{1,2}(i)\ \ldots \beta_{9,10}(i)]'$ is the 56-dimensional vector of metamodel coefficients. Let n=128, the number of design points; let b=8, the number of blocks; and m=16, the size (number of design points) of each block. Finally let $\underset{\sim}{W} = ||w_{rc}||$ denote the so-called <u>block incidence matrix</u> defined as follows:

$$w_{rc} = \begin{cases} +1 & \text{if design point } r \text{ falls in block } c \text{ and } 1 \le c \le b-1 \\ -1 & \text{if design point } r \text{ falls in block } b \text{ and } 1 \le c \le b-1 \\ 0 & \text{otherwise} \end{cases} \tag{3.11}$$

Thus the full design matrix for both the attack and no-attack experiments is

$$\underset{\sim}{D} \equiv \begin{bmatrix} \underset{\sim}{x}_1 & \\ \vdots & \underset{\sim}{W} \\ \underset{\sim}{x}_n & \end{bmatrix} = [\underset{\sim}{X}\ \ \underset{\sim}{W}] \tag{3.12}$$

Let $\underset{\sim}{S}_i$ denote the nx1 vector of sorties flown on day i for all n design points, and let $\underset{\sim}{\varepsilon}(i)$ denote the corresponding nx1 vector of errors. Let $B_c(i)$ denote the random block effect due to block c on day i, $1 \le c \le b$; and let

$$\underset{\sim}{B}(i) \equiv \begin{bmatrix} B_1(i) \\ B_2(i) \\ \vdots \\ B_{b-1}(i) \\ -B_1(i) - \ldots - B_{b-1}(i) - B_b(i) \end{bmatrix} \tag{3.13}$$

denote the bx1 vector of block effects. The overall metamodel for the no-attack case can be compactly summarized in matrix notation as

$$\underset{\sim}{S}_i = \underset{\sim}{X}\,\underset{\sim}{\beta}(i) + \underset{\sim}{W}\,\underset{\sim}{B}(i) + \underset{\sim}{\varepsilon}(i). \tag{3.14}$$

Now since Plan 8.10.16 on page 265 of Anderson and McLean (1984) yields a "completely orthogonal" analysis (assuming 3-factor and higher-order interactions are negligible), we have:

$$\underset{\sim}{D}'\underset{\sim}{D} = \begin{bmatrix} \underset{\sim}{X}' \\ \underset{\sim}{W}' \end{bmatrix} \begin{bmatrix} \underset{\sim}{X} & \underset{\sim}{W} \end{bmatrix}$$

$$= \begin{bmatrix} \underset{\sim}{X}'\underset{\sim}{X} & \underset{\sim}{X}'\underset{\sim}{W} \\ \underset{\sim}{W}'\underset{\sim}{X} & \underset{\sim}{W}'\underset{\sim}{W} \end{bmatrix}$$

$$= \begin{bmatrix} \underset{\sim}{X}'\underset{\sim}{X} & \underset{\sim}{0} \\ \underset{\sim}{0} & 2m\underset{\sim}{I}_{b-1} \end{bmatrix} \tag{3.15}$$

This implies that the ordinary least squares estimation of $\underset{\sim}{\beta}(i)$ is

$$\hat{\underset{\sim}{\beta}}(i) = (\underset{\sim}{X}'\underset{\sim}{X})^{-1}\,\underset{\sim}{X}'\underset{\sim}{S}_i$$

$$= (\underset{\sim}{X}'\underset{\sim}{X})^{-1} \underset{\sim}{X}'[\underset{\sim}{X}\underset{\sim}{\beta}(i) + \underset{\sim}{W}\underset{\sim}{B}(i) + \underset{\sim}{\varepsilon}(i)$$

$$= \underset{\sim}{\beta}(i) + (\underset{\sim}{X}'\underset{\sim}{X})^{-1} \underset{\sim}{X}'\underset{\sim}{\varepsilon}(i) \qquad (3.16)$$

since $\underset{\sim}{X}'\underset{\sim}{W} = \underset{\sim}{0}$.

From (3.16) it follows that

$$\text{Cov}[\hat{\underset{\sim}{\beta}}(i)] = E\{[(\underset{\sim}{X}'\underset{\sim}{X})^{-1}\underset{\sim}{X}'\underset{\sim}{\varepsilon}(i)][(\underset{\sim}{X}'\underset{\sim}{X})^{-1}\underset{\sim}{X}'\underset{\sim}{\varepsilon}(i)]'\}$$

$$= (X'X)^{-1}X'E\{\underset{\sim}{\varepsilon}(i)\underset{\sim}{\varepsilon}'(i)\}\underset{\sim}{X}(\underset{\sim}{X}'\underset{\sim}{X})^{-1}$$

$$= (X'X)^{-1}X'\{\sigma^2_{\varepsilon(i)}\underset{\sim}{I}_n\} X(X'X)^{-1}$$

$$= \sigma^2_{\varepsilon(i)}(\underset{\sim}{X}'\underset{\sim}{X})^{-1} \qquad (3.17)$$

Combining (3.10) and (3.17), we see that the minimum variance unbiased estimator of $\mu_k(i)$, the mean number of sorties flown on Day i at the k^{th} design point, is

$$\hat{\mu}_k(i) \equiv \underset{\sim}{x}_k\hat{\underset{\sim}{\beta}}(i) \qquad (3.18)$$

$$\Rightarrow \text{Var}[\hat{\mu}_k(i)] = \underset{\sim}{x}_k\text{Cov}[\hat{\underset{\sim}{\beta}}(i)]\underset{\sim}{x}'_k$$

$$= \sigma^2_{\varepsilon(i)} \underset{\sim}{x}_k(\underset{\sim}{X}'\underset{\sim}{X})^{-1}\underset{\sim}{x}'_k \ . \qquad (3.19)$$

Similarly, for the attack case we have

$$\underset{\sim}{S}^{*}_i = \underset{\sim}{X}\underset{\sim}{\beta}^{*}(i) + \underset{\sim}{W}\underset{\sim}{\beta}^{*}(i) + \underset{\sim}{\varepsilon}^{*}(i), \qquad (3.20)$$

$$\hat{\underset{\sim}{\beta}}^{*}(i) = (\underset{\sim}{X}'\underset{\sim}{X})^{-1}\underset{\sim}{X}'\underset{\sim}{S}^{*}_i$$

$$= \underset{\sim}{\beta}^{*}(i) + (\underset{\sim}{X}'\underset{\sim}{X})^{-1}\underset{\sim}{X}'\underset{\sim}{\varepsilon}^{*}(i) \qquad (3.21)$$

$$\text{Cov}[\hat{\underset{\sim}{\beta}}^*(i)] = \sigma^2_{\varepsilon(i)}(\underset{\sim}{X}'\underset{\sim}{X})^{-1} ; \tag{3.22}$$

and the minimum variance unbiased estimator of $\mu_k^*(i)$, the mean number of sorties flown on Day i at the k^{th} design point, is

$$\hat{\mu}_k^*(i) \equiv \underset{\sim}{x}_k \hat{\underset{\sim}{\beta}}^*(i) \tag{3.23}$$

with

$$\text{Var}[\hat{\mu}_k^*(i)] = \sigma^2_{\varepsilon^*(i)} \underset{\sim}{x}_k (\underset{\sim}{X}'\underset{\sim}{X})^{-1} \underset{\sim}{x}'_k \ . \tag{3.24}$$

We want to use $\hat{\mu}_k^*(i) - \hat{\mu}_k(i)$ to test the null hypothesis

$$H_0: \mu_k^*(i) = \mu_k(i) \tag{3.25}$$

that there is no difference in the mean number of sorties flown on Day i with and without attacks versus the alternative hypothesis

$$H_1: \mu_k^*(i) < \mu_k(i) \tag{3.26}$$

that fewer sorties are flown in the attack case.

Now if we had run the attack and no-attack cases independently, then we would have had

$$\text{Var}[\hat{\mu}_k^*(i) - \hat{\mu}_k(i)] = \text{Var}[\hat{\mu}_k^*(i)] + \text{Var}[\hat{\mu}_k(i)] \ . \tag{3.27}$$

Because we used the same random numbers for each case, we have instead

$$\text{Var}[\hat{\mu}_k^*(i) - \hat{\mu}_k(i)] = \text{Var}[\hat{\mu}_k^*(i)] + \text{Var}[\hat{\mu}_k(i)]$$

$$- 2\mathrm{Cov}[\hat{\mu}_k^*(i), \hat{\mu}_k(i)] \; ; \tag{3.28}$$

and if the use of common random numbers has been effective in sharpening the comparison of the attack and no-attack cases, we will have

$$\mathrm{Cov}[\hat{\mu}_k^*(i), \hat{\mu}_k(i)] > 0 \tag{3.29}$$

so that the right-hand-side of (3.28) is less than the right-hand-side of (3.27).

From the results of analyzing the data for the $\begin{pmatrix}\text{no-attack}\\ \text{attack}\end{pmatrix}$ case, we have $\begin{pmatrix}SS_{\varepsilon(i)}\\ SS_{\varepsilon^*(i)}\end{pmatrix}$ is the error sum of squares for the metamodel $\begin{pmatrix}(3.14)\\ (3.20)\end{pmatrix}$ on Day i; and $\begin{pmatrix}DF_{\varepsilon(i)}\\ DF_{\varepsilon^*(i)}\end{pmatrix}$ is the corresponding degrees of freedom for error so that the mean square for error is

$$\begin{pmatrix} MS_{\varepsilon(i)} \equiv SS_{\varepsilon(i)}/DF_{\varepsilon(i)} \\ MS_{\varepsilon^*(i)} \equiv SS_{\varepsilon^*(i)}/DF_{\varepsilon^*(i)} \end{pmatrix}.$$

To test H_0 (3.25) we compute

$$t_0 = \frac{\hat{\mu}_k^*(i) - \hat{\mu}_k(i)}{\sqrt{[MS_{\varepsilon(i)} + MS_{\varepsilon^*(i)}]\,[\underset{\sim}{x}_k (\underset{\sim}{X}'\underset{\sim}{X})^{-1} x_k']}}$$

$$= \frac{\underset{\sim}{x}_k [\hat{\underset{\sim}{\beta}}^*(i) - \hat{\underset{\sim}{\beta}}(i)]}{\sqrt{[MS_{\varepsilon(i)} + MS_{\varepsilon^*(i)}]\,[\underset{\sim}{x}_k (\underset{\sim}{X}'\underset{\sim}{X})^{-1} x_k']}} \tag{3.30}$$

and we reject H_0 in favor of H_1 at the α level of significance if

$$t_0 < t_\alpha(v_{eff}), \tag{3.31}$$

where $t_\alpha(v_{eff})$ is the quantile of order α for a Student t-distribution with the so-called "effective degrees of freedom" (Welch, 1947):

$$v_{eff} = \frac{[MS_{\varepsilon(i)} + MS_{\varepsilon^*(i)}]^2}{\left(\frac{[MS_{\varepsilon(i)}]^2}{[DF_{\varepsilon(i)}+2]} + \frac{[MS_{\varepsilon^*(i)}]^2}{[DF_{\varepsilon^*(i)}+2]}\right)} - 2 \tag{3.32}$$

Because of (3.31) and (3.32), this test is <u>conservative</u>, that is, a difference $\hat{\mu}_k^*(i) - \hat{\mu}_k(i)$ that is reported to be significant at the α level of significance is actually significant at an even lower level; thus, significant differences are understated. Finally, a <u>conservative</u> 100(1-α)% confidence interval on the difference $\mu_k^*(i) - \mu_k(i)$ is

$$\underset{\sim}{x}_k[\hat{\underset{\sim}{\beta}}^*(i) - \hat{\underset{\sim}{\beta}}(i)] \pm$$

$$t_{1-\alpha/2}(v_{eff}) \cdot \sqrt{[MS_{\varepsilon(i)} + MS_{\varepsilon^*(i)}][\underset{\sim}{x}_k(\underset{\sim}{X}'\underset{\sim}{X})^{-1}\underset{\sim}{x}_k']} \tag{3.33}$$

<u>Identifying Key Resources Over Time</u>

The last major research objective is to identify key resources and interactions over a thirty-day time period with and without attacks. We have estimated thirty separate daily models and now we want to see if there are resource trends across these models. This evaluation is largely subjective based on the beta coefficients of significant variables in the estimated metamodels. We examine any trends in the coefficients from day to day. We also use the metamodels as predictive tools to estimate the difference in the expected number of sorties flown when a single variable moves from the low level to the high level.

CHAPTER IV - OVERALL EVALUATION OF THE EXPERIMENTAL DESIGN

Results are divided between Chapters IV and V. This chapter focuses on the experimental design and the statistical analysis of the metamodels. Chapter V continues the evaluation of the results by interpreting the metamodels in terms of resource or factor importance to the sortie generation process. Here we first examine how well our design performed in terms of variance reduction and relative efficiency. We then look at the daily predictive metamodels derived from the simulation data and test for normality. Confidence intervals for the mean response are also computed and we examine the sample variances for several cases. Next we evaluate the predictive power of the regression expressions. Finally we test for significant differences between the attack and no-attack cases.

The Effectiveness of the Experimental Design

Our first research objective in this thesis is the development of a statistically controlled experimental design which allows us to estimate metamodels from a relatively small number of runs of a large-scale simulation model. This must be done with acceptable levels of estimated error through the use of variance reduction techniques.

Variance Reduction and Design Efficiency

The experimental design has mixed results in terms of reducing variance by blocking based on common random numbers. Tables 4.1 and 4.2 show the results for the no-attack and attack cases respectively.

The No-Attack Case. The success of the variance reduction technique in this case ranges from a high of 43.72% reduction for the Day 1 results to -4.91% for reduction Day 22. The average variance reduction across all thirty models is only 5.68%. Thus it appears that the blocking scheme based solely on random numbers in the TSAR model is not very effective. In light of the complexity of the model, these results are understandable. Each 30-day run within a block begins Day 1 with the same seed for the random number stream. From this common beginning, the runs begin to diverge in their use of random numbers, some runs using more random numbers than others depending on such events as aircraft losses due to attrition, aircraft battle damage, and failures within any of the 81 aircraft systems/subsystems. As a result of this random divergence in the use of random numbers from the common stream, runs after the very beginning of Day 1 have little or no congruence. Thus, it is not surprising that we find our best results on Day 1. Table 4.3 shows the

Table 4.1

No-Attack Case -- Variance Reduction and Relative Efficiency Due to Blocking

DAY	SS(B1)	SS(B2)	SS(B3)	SS(B4)	SS(B5)	SS(B6)	SS(B7)	SSE	df(E)	% VARIANCE REDUCTION	RELATIVE EFFICIENCY
1	26.8	2.1	9.2	691.3	1256.4	39.0	50.6	2329.1	109	43.72	1.78
2	34.2	529.8	1.7	150.3	319.4	47.8	293.7	18927.1	109	0.80	1.01
3	143.8	785.6	490.6	192.2	542.2	1265.9	312.3	13633.1	108	16.41	1.20
4	0.4	205.4	0.1	57.5	1218.8	708.9	1158.9	16473.6	111	11.66	1.13
5	217.1	209.3	300.6	1625.9	52.6	3.6	107.9	18350.1	109	6.41	1.07
6	23.1	3.5	553.1	0.1	4.6	16.1	2.6	8144.2	100	0.38	1.00
7	0.9	1473.4	450.0	573.8	57.5	2147.1	155.3	20733.3	109	13.78	1.16
8	30.0	17.2	161.2	3016.4	279.0	750.4	4.0	47319.5	108	2.31	1.02
9	1.8	0.1	5.8	743.1	1944.6	56.0	553.1	60642.0	107	-1.04	0.99
10	19.7	6.6	253.9	353.8	24.1	19.7	748.6	13445.3	107	3.68	1.04
11	323.0	32.3	9.9	112.9	88.8	.0	18.9	21465.0	111	-3.48	0.97
12	4.0	385.9	80.2	236.2	66.4	0.2	355.0	22382.0	111	-1.21	0.99
13	24.1	39.0	19.7	5.3	65.9	988.3	1087.2	16862.4	110	6.06	1.06
14	1061.0	52.6	132.8	0.7	0.6	217.1	209.3	23588.1	114	0.89	1.01
15	542.2	0.3	381.9	77.2	0.7	11.8	1.7	18146.9	110	-0.72	0.99
16	387.2	557.9	122.3	16.9	117.9	0.1	9.7	18704.4	105	-0.18	1.00
17	1200.2	85.6	90.7	1387.5	793.1	2.3	11.4	15570.7	105	13.23	1.15
18	1588.4	156.9	113.6	177.7	86.9	.0	0.1	13002.9	102	8.14	1.09
19	2477.8	562.6	187.6	2907.4	1287.4	96.5	443.0	32352.4	102	14.24	1.17
20	37.0	308.8	43.8	1067.5	940.5	26.5	1211.8	19975.6	105	9.76	1.11
21	41.6	381.9	199.7	1583.1	77.2	217.1	73.7	15454.2	99	8.22	1.09
22	0.3	22.8	23.5	60.6	98.4	47.8	10.1	17548.8	108	-4.91	0.95
23	60.6	351.3	698.3	97.1	60.6	0.1	115.0	15436.6	104	2.04	1.02
24	73.1	1188.6	1045.8	658.3	330.3	330.3	340.1	16719.4	106	13.84	1.16
25	275.7	13.8	52.6	25.4	458.6	1131.8	7.0	20580.9	110	2.91	1.03
26	43.8	932.4	575.4	72.0	238.2	661.7	661.7	24138.5	104	5.71	1.06
27	840.9	36.2	6.4	161.2	129.0	451.4	429.0	43304.0	109	-1.60	0.98
28	780.0	429.0	4.0	65.4	54.0	70.9	135.2	34719.3	105	-2.14	0.98
29	1047.9	68.1	0.1	199.7	1009.4	23.5	3.6	27384.2	103	1.65	1.02
30	511.5	19.7	7.7	473.0	902.0	27.5	39.9	31300.6	110	-0.03	1.00

Table 4.2

Attack Case -- Variance Reduction and Relative Efficiency Due to Blocking

DAY	SS(B1)	SS(B2)	SS(B3)	SS(B4)	SS(B5)	SS(B6)	SS(B7)	SSE	df(E)	% VARIANCE REDUCTION	RELATIVE EFFICIENCY
1	1092.0	218.0	3263.5	146.3	5178.3	1385.0	124.5	11933.8	119	47.66	1.91
2	780.0	59990.0	15012.2	665.2	39379.0	5035.0	22923.0	29622.8	109	81.90	5.53
3	1738.3	7544.6	10206.0	14657.8	928.3	74606.0	21607.1	69596.8	112	63.19	2.72
4	255.0	1.6	16099.1	1601.8	5352.8	3009.1	3038.5	45045.7	110	35.60	1.55
5	930.3	9148.2	51865.5	424.9	59.6	132.8	2548.1	65974.1	110	46.47	1.87
6	17404.7	1724.4	4658.3	2349.8	4024.8	1313.9	12939.8	113693.3	111	23.56	1.31
7	13076.9	517.6	9679.7	1323.6	5525.3	684.3	26306.9	77682.3	110	38.70	1.63
8	8995.4	0.1	3848.7	606.2	3848.7	1113.8	11364.4	95926.4	112	18.92	1.23
9	8477.2	5.2	5620.0	2405.2	4773.0	2484.4	17537.2	75240.5	111	31.37	1.46
10	7314.3	108.6	8452.6	340.1	3745.8	658.3	18871.1	82737.0	111	28.04	1.39
11	4828.6	25.8	3778.6	48.3	5362.6	1501.8	16663.5	62997.8	107	29.50	1.42
12	5226.4	154.4	5822.2	75.4	4771.0	1390.0	20026.4	54340.0	106	36.90	1.58
13	6466.1	179.5	4460.8	716.1	3094.0	319.4	24601.6	61403.4	112	35.56	1.55
14	6007.1	4.6	5204.6	1921.1	4791.5	1992.1	25457.8	60149.3	108	39.35	1.65
15	7200.4	105.9	2646.9	2987.2	6754.0	2125.4	21177.2	62670.9	110	36.92	1.59
16	8932.2	.0	2222.0	2171.9	6274.2	1145.3	17475.3	55196.5	112	37.22	1.59
17	5505.4	24.1	1837.2	1328.4	6574.0	561.0	23176.6	53874.8	107	38.20	1.62
18	7245.9	5.2	810.2	396.4	4097.2	679.0	12630.0	50760.6	107	29.42	1.42
19	6748.5	79.6	1935.8	1145.3	5387.1	583.4	15469.6	53880.2	108	32.68	1.49
20	8004.1	15.5	2244.1	1050.1	4088.6	55.0	14256.1	40741.1	104	38.28	1.62
21	7667.0	32.6	2375.8	1488.9	2954.4	376.7	15753.4	36674.2	107	41.96	1.72
22	5924.6	44.6	2263.1	2016.0	1263.5	200.6	11257.8	31121.4	104	38.59	1.63
23	8106.1	5.6	2091.7	979.9	2889.4	300.6	9561.8	40004.1	109	33.42	1.50
24	6396.5	703.6	5352.8	1375.1	1845.8	342.5	10111.7	32767.4	107	40.72	1.69
25	5495.5	314.7	2330.4	2461.2	2203.2	333.9	11165.8	31433.8	107	39.92	1.66
26	7065.0	17.2	2871.4	1727.2	2646.9	117.2	8825.2	32672.3	110	37.88	1.61
27	6776.0	37.8	3001.8	1874.6	1063.1	23.1	9001.8	21695.3	104	46.74	1.88
28	6579.4	7.9	1956.4	780.0	986.2	75.4	8625.4	24887.1	105	39.53	1.65
29	5535.2	19.2	1294.6	1707.8	1163.4	11.4	7377.3	22791.4	106	39.11	1.64
30	4964.2	54.5	1680.3	1232.8	1270.6	90.7	5347.9	21159.6	109	37.10	1.59

Table 4.3

No-Attack Case -- Computer Run Times (Seconds)

TREATMENT	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	BLOCK 6	BLOCK 7	BLOCK 8
1	251.94	245.54	322.90	181.30	174.22	273.66	229.24	200.68
2	281.72	166.64	249.54	225.40	199.20	200.68	183.90	260.12
3	222.10	225.16	167.56	300.96	259.36	178.12	240.80	204.86
4	184.26	275.84	192.16	223.98	218.16	228.48	255.48	169.12
5	306.62	168.74	198.92	206.56	194.54	254.14	199.68	263.48
6	204.36	224.08	287.78	176.12	164.36	290.10	239.78	203.38
7	174.24	288.72	193.60	225.56	196.44	239.08	317.36	152.38
8	200.66	213.42	178.92	294.16	274.98	172.26	259.72	218.60
9	284.06	154.26	204.24	243.14	200.30	234.36	177.76	250.46
10	206.04	212.74	323.22	174.68	172.08	255.06	225.96	205.34
11	171.26	302.36	231.04	202.16	199.58	220.34	312.56	167.90
12	199.08	231.02	168.58	266.20	291.04	164.28	231.26	240.62
13	212.16	218.30	309.98	154.32	168.02	255.10	205.62	226.78
14	315.06	181.22	247.94	211.30	191.48	187.12	168.76	297.70
15	214.98	220.28	189.98	268.96	286.78	185.70	249.68	240.38
16	162.22	245.62	194.98	219.82	211.04	242.42	303.78	155.74

TOTAL TIME: 28642.02 seconds or 477.37 minutes
AVERAGE TIME: 223.77 3.73

computer run times for the TSAR simulation by treatment for the no-attack case. Each run of TSAR averaged 3.73 minutes on a Gould NP-1 supercomputer for a total of 477.37 minutes for the entire no-attack case.

The Attack Case. The success of the variance reduction technique is more apparent in this case, ranging from a low of 18.92% on Day 8 to a high of 81.90% on Day 2. The average percent reduction in variance is 38.81%. Here we see that the blocking based on the seeds for the TSARINA attacks, as well as on the random number streams for the logistics processes in TSAR, is much more effective in reducing the variance. Table 4.4 shows the computer run times for the TSAR model when attacks were present. The runs averaged 2.79 minutes or a total of 357.02 minutes on a Gould NP-1 supercomputer. While the simulations for this case do not take as much computer time as in the no-attack case, the cost of additional replication would still be significant, especially considering the magnitude of the experiment and the computer time involved.

Summary. A single replication of the experiment costs over 13.9 hours of computer time for the TSAR model when run on a Gould NP-1 supercomputer. Computer times for the TSARINA attacks were not tracked but are very small in comparison to the TSAR run times since TSARINA runs much faster and only eight attacks were used (one for each block). Based on the magnitude of the computer time, it is

Table 4.4

Attack Case -- Computer Run Times (Seconds)

TREATMENT	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	BLOCK 6	BLOCK 7	BLOCK 8
1	65.44	197.14	225.36	135.90	159.38	175.04	161.66	170.92
2	80.26	152.74	117.62	213.84	173.42	143.90	119.82	212.70
3	192.30	161.40	142.44	207.04	214.66	134.70	145.10	207.10
4	177.90	223.46	140.84	144.06	156.96	203.68	124.28	140.94
5	146.26	136.00	170.82	211.22	172.44	118.20	144.12	226.82
6	113.80	198.92	251.82	156.84	134.44	187.84	162.72	150.24
7	140.96	178.42	201.26	138.50	142.42	192.36	223.46	164.54
8	171.86	116.00	148.96	180.16	192.28	108.04	94.52	186.78
9	192.74	145.22	182.24	221.86	164.30	150.90	103.84	269.02
10	175.14	176.10	246.48	121.64	125.50	202.80	63.16	171.66
11	152.52	228.52	202.60	128.08	170.64	167.92	193.22	145.08
12	171.92	180.30	161.66	221.18	186.78	158.34	128.02	186.40
13	146.10	189.94	214.68	115.16	155.46	182.06	163.84	173.42
14	194.56	171.14	176.90	172.94	200.40	187.46	64.82	243.28
15	161.36	153.14	140.98	190.68	222.58	153.20	150.12	138.34
16	171.58	245.14	197.10	139.36	155.52	178.12	136.52	154.28

TOTAL TIME: 21420.98 seconds or 357.02 minutes

AVERAGE TIME: 167.35 2.79

undesirable to needlessly replicate the experiment. Thus the variance reduction results for this large-scale simulation model and problem are beneficial.

The Daily Metamodels

Another research objective is the estimation of simpler metamodels from the simular responses. Before deriving the daily metamodels, we test whether sorties are normally distributed for each case. Then we compute some sample and population statistics for selected design points and days. Next, using regression, we derive a metamodel for each day in each case (no-attack and attack). Each is a reduced model with all factors (except the blocking factors) significant at the 0.10 level; models are presented by case. For each model, we examine the coefficient of multiple determination (R^2) and the residuals to determine the aptness of the model. Interpretations of the models over the entire thirty-day time period are reserved for Chapter V.

Coding of the Design Matrix

Before discussing the results of the analyses in this research, we must first be aware of the method used to code the indicator variables associated with the resource/policy variables and the blocks. Resource variables are coded such that

X_{ij} = 1 if resource j is at the high level on Day 1,

X_{ij} = 0 if resource j is at the low level on Day 1, for $j = 1,2,\ldots,10$.

Block variables are coded such that

B_k = 1 if observation is from block k

= -1 if observation is from block 8

= 0 otherwise

for $k = 1,2,\ldots,7$.

This coding scheme yields sound results in our comparative analyses where the intercept term reflects the case where all resource/policy variables are at the low level. The beta coefficients then reflect the change in sorties flown when the factor or interaction term moves from the low level to the high level. However, with our coding scheme, the beta coefficients are not the exact effect of the factor's resource level and a transformation is needed to isolate the effect. These transformations are possible conceptually, but computationally they are very involved and complicated. The exact effect of each resource/policy variable can be computed by using the following coding scheme:

X_{ij} = 1 if resource j is at the high level on Day 1,

= -1 if resource j is at the low level on Day 1,

for $j = 1,2,\ldots,10$.

Appendix A shows the equivalency of the two model forms.

Since the analysis results are not affected, we leave the coding as is for this research. Future analyses will incorporate a consistent coding scheme for the resources using (1,-1) in place of (1,0) respectively to denote high and low resource levels if one desires the beta coefficients to reflect the exact effect of each factor or interaction.

Test for Normality

The Shapiro-Wilk test is used to determine whether daily sorties are likely to be normally distributed. We compute 6 Shapiro-Wilk test statistics for each case (i.e., attack and no-attack) based on 20 independent replications. Within each case, we test for normality on Days 1, 5, and 30 for design point (a) where all factors are at the high level, and design point (b) where all factors are at the low level. Sample statistics and the results of the normality tests are shown in Table 4.5.

The Shapiro-Wilk test results indicate that, for the most part, daily sortie counts appear to be normally distributed based on the six selected design points for each case. Three exceptions are noted in Table 4.5 for which standard normal quantile plots are shown in Figures 4.1 - 4.3. With the exception of Day 1 of the attack case when all factors are low, there are no major departures from the assumption of normality. Additional Shapiro-Wilk tests were conducted for Days 2-4 of the attack case with all factors low to see if sortie counts for these days also appeared to be nonnormal. The results indicated that we would accept the null hypothesis of normal distribution of sortie counts. Given the overall results we conclude that daily sortie

Table 4.5

Sample Statistics and Shapiro-Wilk Test Results

NO-ATTACK CASE

	All Factors High			All Factors Low		
	Day 1	Day 5	Day 30	Day 1	Day 5	Day 30
Sample Mean	266.3	215.4	70.0	262.0	183.4	55.6
Sample Variance	59.99	107.31	182.84	59.26	267.94	117.00
Shapiro-Wilk Statistic W	0.9553	0.8376	0.9576	0.9693	0.9625	0.9448
Significance Probability	0.4636	0.0027	0.5043	0.7323	0.5974	0.3066
Ho: Normal	Accept	Reject	Accept	Accept	Accept	Accept

ATTACK CASE

	All Factors High			All Factors Low		
	Day 1	Day 5	Day 30	Day 1	Day 5	Day 30
Sample Mean	112.0	127.0	50.1	87.4	89.0	33.5
Sample Variance	711.73	701.52	372.79	763.31	1138.47	213.10
Shapiro-Wilk Statistic W	0.9561	0.8643	0.9851	0.7403	0.9746	0.9340
Significance Probability	0.4770	0.0085	0.9710	0.0001	0.8335	0.1948
Ho: Normal	Accept	Reject	Accept	Reject	Accept	Accept

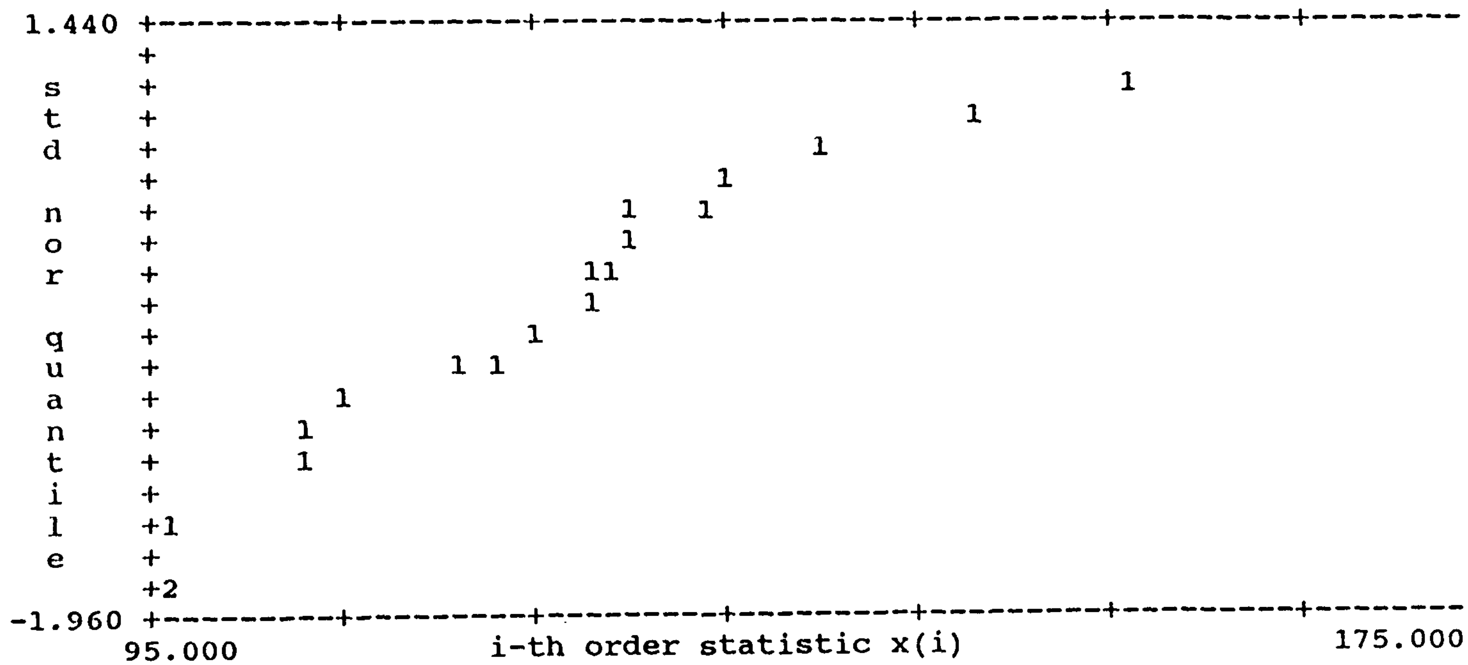


Figure 4.1

Normal Quantile Plot -- All Factors High, Attack Case, Day 5

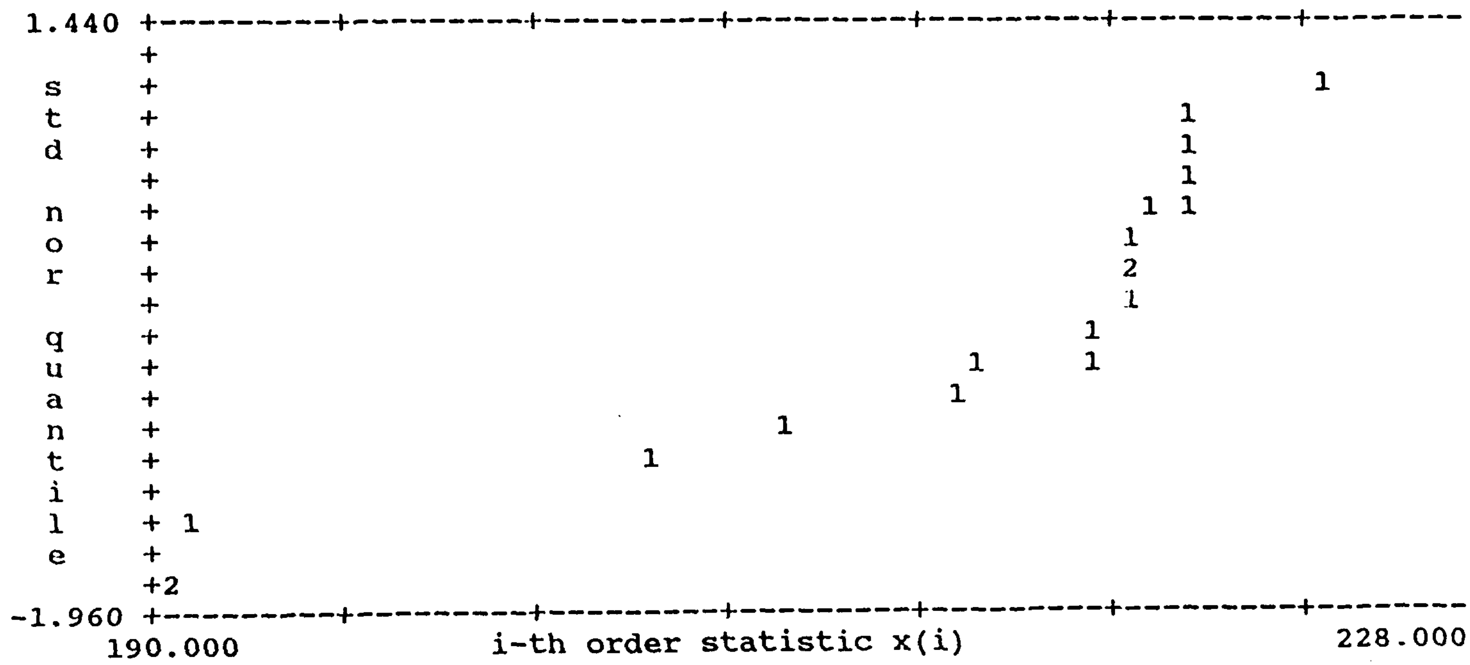


Figure 4.2

Normal Quantile Plot -- All Factors High, No-Attack Case, Day 5

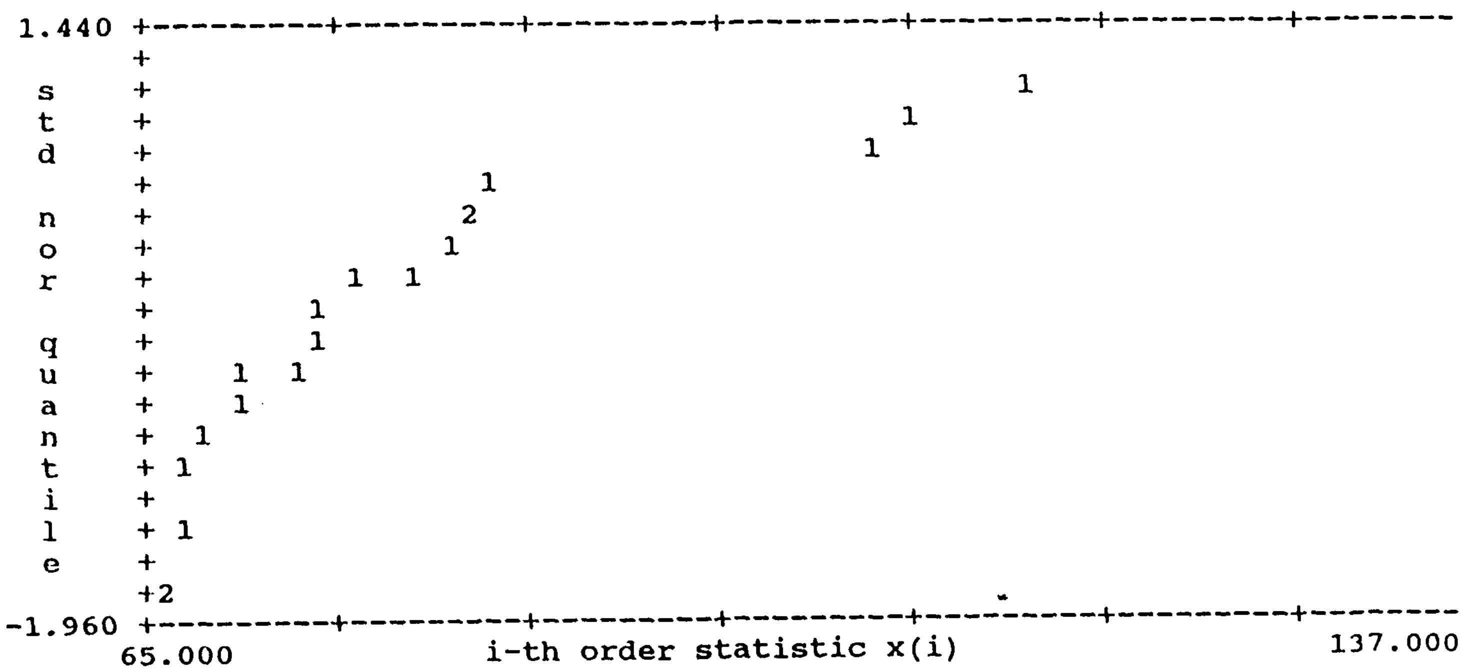


Figure 4.3

Normal Quantile Plot -- All Factors Low, Attack Case, Day 1 counts for both cases appear to follow the normal distribution.

Possibly contributing to nonnormality for the attack case are four treatments where the air base never recovers from the attacks during Days 1-5. These are unlikely situations since it is more probable that human ingenuity would find ways to circumvent almost any problem to restore flying operations to some minimum level during the thirty-day period. These four cases appear to be a failure of TSAR to model this type of situation rather than probable occurrences. However, the cases were left in the analysis as representative of worst case situations.

Statistics For Design Point k

Here we focus on our two selected design points, (a) all factors high and (b) all factors low.

Confidence intervals for $\mu_k(i)$, the mean number of sorties flown on Day i = 1, 5, 30 at design point k=a,b for the no-attack case, and the same measure, $\mu_k^*(i)$, for the attack case, are shown in Tables 4.6 and 4.7, respectively. These 95% confidence intervals are based on equations (3.7) and (3.8).

For the most part, the widths of these 95% confidence intervals for the mean response are reasonably narrow. All of the sample means (except one) from our 20 independent replications fall within their respective confidence

Table 4.6

Confidence Intervals for $\mu_k(i)$ in the No-Attack Case

	$MS_{\varepsilon(i)}$ ($DF_{\varepsilon(i)}$)	$t_{.975, DF\varepsilon(i)}$	LOWER (Sorties)	$\underset{\sim}{x}_k \hat{\underset{\sim}{\beta}}_k(i)$	UPPER (Sorties)
DESIGN POINT (a)					
Day 1	21.3676 (109)	1.9822	253.3	259.4	265.5
Day 5	168.3494 (109)	1.9822	199.1	216.1	233.1
Day 30	284.5514 (110)	1.9818	35.3	57.4	79.5
DESIGN POINT (b)					
Day 1	21.3676 (109)	1.9822	257.6	263.7	269.8
Day 5	168.3494 (109)	1.9822	160.2	177.2	194.2
Day 30	284.5514 (110)	1.9818	40.8	62.9	85.0

Table 4.7

Confidence Intervals for $\mu_k^*(i)$ in the Attack Case

	$MS_{\varepsilon^*(i)}$ ($DF_{\varepsilon^*(i)}$)	$t_{.975,DF\varepsilon^*(i)}$	LOWER (Sorties)	$\underset{\sim}{x}_k\hat{\underset{\sim}{\beta}}^*_k(i)$	UPPER (Sorties)
<u>DESIGN POINT (a)</u>					
Day 1	100.2844 (119)	1.9799	88.5	101.6	114.7
Day 5	599.7648 (110)	1.9818	99.3	131.4	163.5
Day 30	194.1248 (109)	1.9822	40.1	58.4	76.7
<u>DESIGN POINT (b)</u>					
Day 1	100.2844 (119)	1.9799	64.6	77.7	90.8
Day 5	599.7648 (110)	1.9818	39.7	71.8	103.9
Day 30	194.1248 (109)	1.9822	5.0	23.3	41.6

interval. The one exception (Day 1, all factors high, no-attack case) exceeds the upper limit by less than 1 sortie.

Figure 4.4 compares the confidence intervals given in Tables 4.6 and 4.7. On Day 1 we see that there appears to be definite differences between the attack and no-attack cases, although the confidence intervals do overlap within each case for design point (a) and (b). By Day 5 the confidence intervals are wider for all four case-design point combinations, but have moved closer to each other with some overlapping. By Day 30, the confidence intervals are nearly the same, indicating that previous differences tend to balance out in the long run.

Homogeneity of variance test results are shown in Table 4.8. The results for the within-case variance all indicate that the null hypothesis of equal variances at design points for Day i should not be rejected. This is important since many (128) design points are used to estimate each daily metamodel and homoscedasticity is a requirement for minimum variance unbiased estimators using ordinary least squares procedures (Neter et al., 1985). In contrast, Table 4.8 results for between-cases variance indicate that we should reject the null hypothesis and accept the alternate hypothesis of unequal variances between the no-attack and attack cases for the same day and design point. This supports the experimental design decision to keep the two cases separate. One exception to note is that we do not

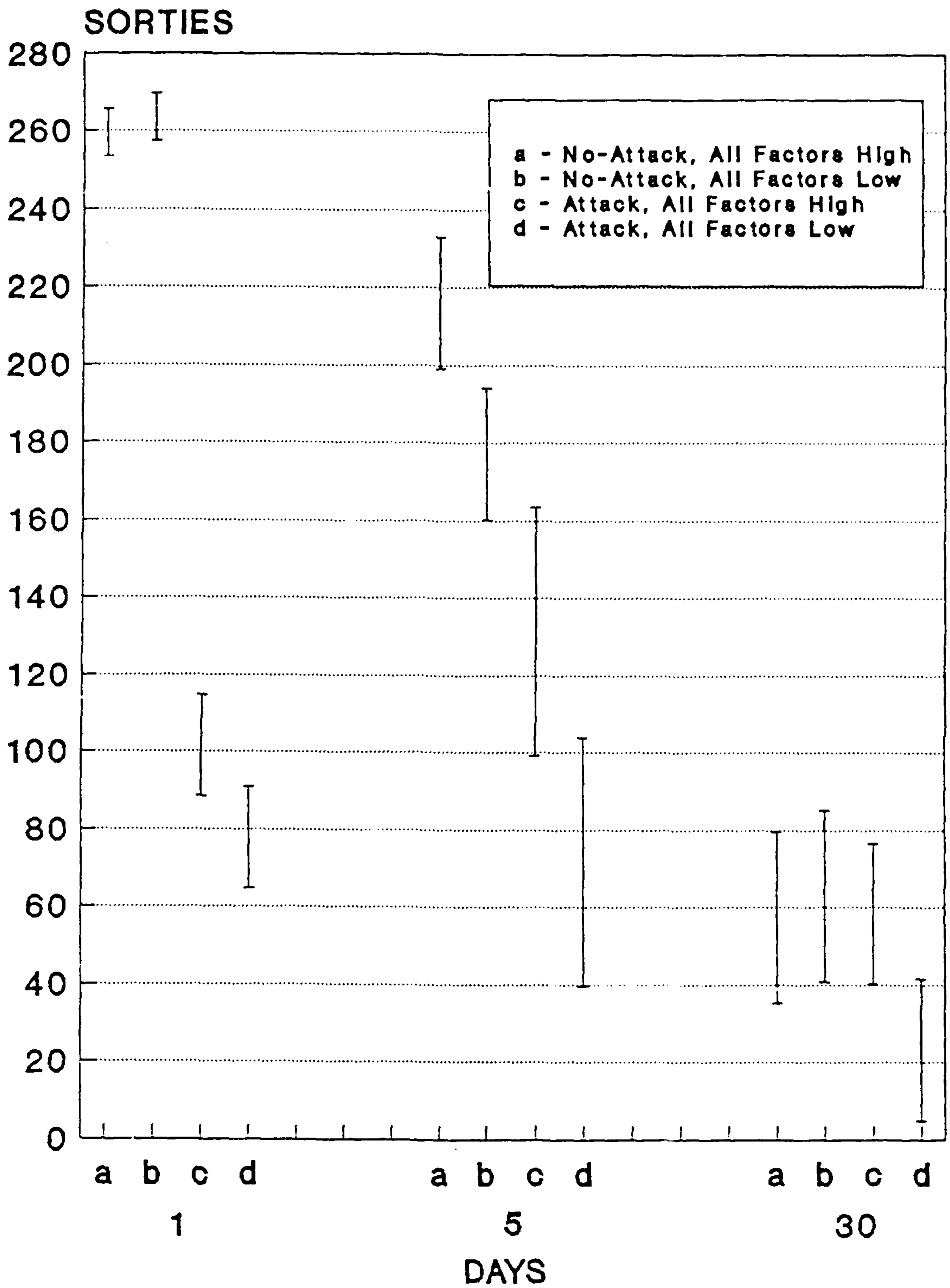


Figure 4.4

Confidence Intervals for Mean Responses

Table 4.8

Results for Homogeneity of Variance Tests

	CASE		
	NO-ATTACK $\hat{\sigma}^{2}_{ik}$	ATTACK $\hat{\sigma}^{*2}_{ik}$	$F = \hat{\sigma}^{*2}_{ik} / \hat{\sigma}^{*2}_{ik}$ (between)
DESIGN POINT (a)			
Day 1	59.99	711.73	711.73/59.99 = 11.86 reject H_0
Day 5	107.31	701.52	701.52/107.31 = 6.54 reject H_0
Day 30	182.84	372.79	372.79/182.84 = 2.04 accept H_0
DESIGN POINT (b)			
Day 1	59.26	763.31	763.31/59.26 = 12.88 reject H_0
Day 5	267.94	1138.47	1138.47/267.94 = 4.25 reject H_0
Day 30	117.00	213.10	213.10/117/00 = 1.82 accept H_0
$F(\text{within}) = \hat{\sigma}^{2}_{ia} / \hat{\sigma}^{2}_{ib}$			
Day 1	59.99/59.26=1.01 accept H_0	763.31/711.73=1.07 accept H_0	H_0: equal variance
Day 5	267.94/107.31=2.50 accept H_0	1138.47/701.52=1.62 accept H_0	H_1: nonequal variance
Day 30	182.84/117.00=1.56 accept H_0	372.79/213.10=1.75 accept H_0	

reject the null hypothesis for Day 30. It seems that the differential effect of the attacks has dissipated by then. Overall, then it appears that variance is homogeneous within cases, but heterogeneous between cases.

Summary. As a result of the normality and variance tests, we conclude that the data contain no major departures from the assumptions of normality and homoscedasticity. The differences in variance between the two cases necessitate the use of special procedures as presented in Chapter III to allow comparisons of the attack and no-attack cases.

Metamodels for the No-Attack Case

Table 4.9 summarizes the estimated daily metamodels for the no-attack case. The beta coefficients for each model are shown only when that main effect or interaction term is significant. The beta coefficient represents the change in number of sorties flown when a factor is at the high level as opposed to the low level. While individual beta coefficients provide some insights into the importance of a main effect, we must reserve conclusions until the effects of all two-way interactions have also been included. These analyses are found in Chapter V for each main effect and its interactions. Complete regression results for each estimated metamodel are found at Appendix A.

Coefficients of multiple determination are summarized in Table 4.10. For the reduced daily models, the R^2 values

Table 4.9

No-Attack Case -- Daily Metamodels

$\alpha = .10$		Attrition	Fillers	ABDR	Recovery	Personnel	AIS	Spt Equip	Spares	Missiles	Fuel
DAY	INTERCEPT	A	B	C	D	E	F	G	H	J	K
1	263.7	-3.0					4.2	5.2			
2	187.2		7.4		11.0	20.8		8.0		19.0	
3	205.1	-8.4				19.2					-14.5
4	194.1					10.6				11.4	
5	177.2		18.5			11.5			14.9		
6	182.3			8.6			-6.0				-17.8
7	184.3							-10.8		-9.7	
8	166.2	-9.1			-10.1				19.6	-12.1	
9	155.0		-21.5	-9.5		-42.9			13.6		
10	140.1		30.4				11.4		10.7		
11	149.5	6.4	44.3						16.9		-13.8
12	145.0		40.5					-13.7			
13	135.2		39.4								
14	131.3		23.5						15.7		
15	122.4		22.2						14.5		
16	117.7		33.0	-9.7	-5.7			11.1			
17	111.9		39.5		-7.1						
18	113.7		9.8			-9.8	14.8	-11.0			
19	115.5		12.9								-29.3
20	98.0		9.0	-11.9	13.7						
21	93.1		23.9			-16.6	11.1				
22	83.6		29.5	-6.4		-6.0			15.9	7.3	
23	79.9		25.2	-11.8			14.4				
24	79.1		19.6			-12.5	7.8				
25	79.4	-11.4	24.1			-12.7					
26	73.5		36.5								-12.9
27	67.5			-12.2	11.9						
28	60.8	16.0	-19.1							-19.8	
29	70.4		-28.6		-11.6		-8.3			-14.5	-13.0
30	62.9		-40.2						-8.8	-16.1	

Table 4.9, continued

DAY	Attrition x Fillers AB	x ABDR AC	x Recovery AD	x Personnel AE	x AIS AF	x Spt Equip AG	x Spares AH	x Missiles AJ	x Fuel AK	Fillers x ABDR BC	x Recovery BD
1		6.8				-3.6					2.2
2									7.3		-8.9
3									9.2		
4											
5			-5.4						5.6		
6	-5.5		-6.9	5.4			4.3		9.5	5.5	4.8
7						6.6				7.2	7.0
8						14.1					
9				-16.1					13.7		
10	-8.7					8.0					
11	-9.4										
12					7.5						
13		-9.0		6.4							
14											11.3
15	7.1			7.8							7.1
16	-10.9							9.4		13.8	
17											
18			-5.8						7.6	12.4	6.8
19										15.0	
20		7.3									14.1
21			-7.1	6.7						6.1	6.9
22									5.0	7.8	
23		10.9			-6.6					8.0	
24	9.2					5.7	-6.9				7.6
25		13.8		13.8							
26								-7.9	8.4	13.5	
27											
28					-13.6	-10.7				-11.0	
29			12.7			-8.1				-8.7	
30											

Table 4.9, continued

DAY	Fillers x Personnel BE	x AIS BF	x Spt Equip BG	x Spares BH	x Missiles BJ	x Fuel BK	ABDR x Recovery CD	x Personnel CE	x AIS CF	x Spt Equip CG	x Spares CH
1		-2.7					-2.5		-2.5		
2					-9.1						
3		-6.1		5.4	-6.9	9.0					
4				6.5	8.8						
5				-12.1	7.9	-7.9					
6	6.9		-4.8		16.3				-5.5		
7			8.7		7.1			-6.4			
8	-18.0		11.0		31.5						
9					50.7				15.9		
10					9.0						
11											
12											
13								9.0			7.9
14	13.5										
15		7.2			6.7		-5.2				
16	7.6			9.6				9.1			
17		8.4	6.3		-9.9			6.1		-6.7	
18	15.9	10.4	8.1						-12.4		
19					-12.6	22.4		13.9			
20			9.1		-11.4	18.6		17.5			
21	14.8			10.4		-11.2			-9.8		
22			10.2			-11.2					
23				13.7							
24				6.7			-6.9				
25	-8.6				12.3						-6.2
26	-21.9			-13.9	14.7		-9.0				
27	-11.0			-24.5	13.9	26.4		11.3			
28				-18.9		47.4					
29				-17.2		48.7					
30				-13.7	14.9	40.7					

Table 4.9, continued

	ABDR x Missiles	x Fuel	Recovery x Personnel	x AIS	x Spt Equip	x Spares	x Missiles	x Fuel	Personnel x AIS	x Spt Equip	x Spares	x Missiles
DAY	CJ	CK	DE	DF	DG	DH	DJ	DK	EF	EG	EH	EJ
1	-3.4											
2							-14.1				7.1	
3				5.9		-8.2	7.9					
4	-8.2			4.8							-5.6	
5		6.5							6.9			
6	-10.2								7.0	5.6		
7								-9.5				15.1
8				11.6							-19.9	31.5
9			-11.3							20.7		59.2
10									-9.1	8.2		15.2
11	-7.0	7.9										
12					-8.8	11.4				10.3		
13								5.8				
14	-5.0					-7.9						
15											-8.6	
16								10.8				-8.9
17						9.5	8.1					
18									-8.8		9.2	
19		-14.2	-11.1			-9.5		13.2		-9.3	-8.7	-22.2
20			-13.5		-14.7							-14.6
21							7.1				8.7	
22											7.5	
23			-5.6			7.0				7.2		
24	7.6										7.6	8.6
25		-11.0				6.5						
26	9.0						-7.1	10.0	-9.3			
27			-17.5						-12.0			
28	15.1	-9.9		8.3							-8.2	
29	8.4	-9.2						10.8				
30												

Table 4.9, continued

DAY	Personnel x Fuel EK	AIS x Spt Equip FG	x Spares FH	x Missiles FJ	x Fuel FK	Spt Equip x Spares GH	x Missiles GJ	x Fuel GK	Spares x Missiles HJ	x Fuel HK	Missiles x Fuel JK
1		-5.2									
2							-11.8				
3										11.3	
4	7.8										-13.4
5			-7.5								
6	5.0				10.9					6.8	
7	9.9										
8						-17.7					
9		-13.1								-15.2	
10	-6.4	-6.8			5.3	-7.9					
11	9.6								-12.7		
12						12.0	7.7		-6.7		
13			6.5			7.8		-6.6	-5.6		
14											
15					-7.8						
16		-6.9	6.0					-6.9			
17			9.8	-6.3	-5.7	7.7			-6.4		8.1
18					-7.5	9.2	7.4		-9.7		
19	14.1						11.0		-11.0	24.8	15.3
20					-8.1	7.4					10.9
21		-6.3	11.6	-13.1		7.5	7.0		-8.5	-8.2	9.3
22									-15.2	-7.8	
23	-13.0	-9.0		-6.8			9.0		-7.1		6.7
24	-10.1			-10.4							
25											
26		6.3				-7.1				8.0	
27							-8.3		11.8		
28	-9.7								14.4		18.0
29	-11.5				11.2				8.7		22.2
30	-13.3						-7.0		15.3		22.8

Table 4.9, continued

If Bi = 1 then Block i
If Bi = -1 then Block 8
Otherwise Bi = 0

DAY	B1	B2	B3	B4	B5	B6	B7
1	-1.2	-0.3	-0.7	-6.1	8.3	-1.5	1.7
2	-1.4	5.4	-0.3	-2.9	-4.2	-1.6	4.0
3	2.8	6.6	5.2	3.2	-5.4	-8.3	-4.1
4	0.1	-3.4	0.1	1.8	-8.2	-6.2	8.0
5	-3.4	-3.4	4.1	9.4	-1.7	-0.4	2.4
6	-1.1	0.4	5.5	0.1	0.5	0.9	-0.4
7	0.2	9.0	-5.0	5.6	-1.8	-10.8	2.9
8	-1.3	-1.0	-3.0	12.8	-3.9	-6.4	-0.5
9	0.3	0.1	0.6	6.4	-10.3	1.8	5.5
10	-1.0	-0.6	-3.7	4.4	1.1	-1.0	6.4
11	4.2	1.3	-0.7	-2.5	2.2	0.0	1.0
12	0.5	4.6	2.1	-3.6	-1.9	-0.1	4.4
13	1.1	1.5	-1.0	-0.5	1.9	-7.4	7.7
14	7.6	-1.7	-2.7	-0.2	0.2	-3.4	-3.4
15	-5.4	-0.1	-4.6	2.1	-0.2	0.8	0.3
16	4.6	-5.5	-2.6	-1.0	2.5	-0.1	0.7
17	8.1	2.2	2.2	-8.7	-6.6	0.4	0.8
18	9.3	-2.9	-2.5	-3.1	-2.2	0.0	0.1
19	11.6	-5.5	3.2	-12.6	8.4	-2.3	-4.9
20	1.4	4.1	1.5	-7.6	7.2	-1.2	-8.1
21	1.5	4.6	-3.3	-9.3	-2.1	3.4	2.0
22	0.1	1.1	-1.1	-1.8	-2.3	1.6	0.7
23	1.8	4.4	-6.2	-2.3	1.8	-0.1	2.5
24	-2.0	8.1	-7.6	-6.0	-4.3	4.3	4.3
25	-3.9	0.9	-1.7	1.2	-5.0	7.9	0.6
26	-1.5	7.1	-5.6	-2.0	-3.6	6.0	6.0
27	-6.8	1.4	0.6	3.0	-2.7	5.0	4.8
28	-6.5	4.8	0.5	1.9	1.7	-2.0	2.7
29	-7.6	1.9	-0.1	3.3	7.4	-1.1	-0.4
30	-5.3	-1.0	0.6	5.1	7.0	-1.2	-1.5

Table 4.10

No-Attack Case -- Regression Statistics

	FULL MODEL				REDUCED MODEL			
DAY	R2	MSE	F	PROB>F	R2	MSE	F	PROB>F
1	0.651	28.69	1.96	0.0041	0.564	21.4	7.85	0.0001
2	0.676	226.97	2.19	0.0010	0.585	173.6	8.53	0.0001
3	0.698	160.48	2.42	0.0003	0.605	126.2	8.71	0.0001
4	0.609	194.55	1.63	0.0258	0.491	148.4	6.69	0.0001
5	0.642	216.71	1.88	0.0063	0.534	168.3	6.93	0.0001
6	0.790	100.28	3.94	0.0001	0.738	81.4	10.4	0.0001
7	0.637	231.91	1.84	0.0080	0.501	190.2	6.08	0.0001
8	0.641	542.60	1.88	0.0065	0.519	438.1	6.13	0.0001
9	0.815	665.48	4.63	0.0001	0.741	566.7	15.33	0.0001
10	0.823	160.81	4.88	0.0001	0.772	125.7	18.15	0.0001
11	0.795	267.26	4.05	0.0001	0.746	193.4	20.38	0.0001
12	0.807	255.30	4.37	0.0001	0.739	201.6	19.66	0.0001
13	0.847	183.69	5.79	0.0001	0.783	153.3	23.41	0.0001
14	0.756	284.99	3.25	0.0001	0.690	206.9	19.48	0.0001
15	0.802	218.01	4.24	0.0001	0.746	165.0	19.01	0.0001
16	0.838	224.15	5.43	0.0001	0.792	178.1	18.18	0.0001
17	0.871	170.94	7.07	0.0001	0.819	148.3	21.62	0.0001
18	0.858	152.77	6.35	0.0001	0.814	127.5	17.90	0.0001
19	0.740	403.66	2.98	0.0001	0.679	317.2	8.63	0.0001
20	0.782	224.34	3.76	0.0001	0.701	190.2	11.21	0.0001
21	0.843	194.72	5.62	0.0001	0.808	156.1	14.90	0.0001
22	0.798	196.03	4.14	0.0001	0.722	162.5	14.73	0.0001
23	0.827	187.48	5.00	0.0001	0.780	148.4	16.08	0.0001
24	0.816	177.63	4.68	0.0001	0.735	157.7	14.00	0.0001
25	0.731	232.84	2.85	0.0001	0.634	187.1	11.21	0.0001
26	0.705	295.20	2.50	0.0002	0.629	232.1	7.65	0.0001
27	0.640	468.07	1.86	0.0070	0.487	397.3	5.76	0.0001
28	0.711	427.46	2.58	0.0001	0.639	330.7	8.44	0.0001
29	0.763	337.58	3.38	0.0001	0.705	265.9	10.24	0.0001
30	0.752	362.34	3.18	0.0001	0.670	284.6	13.15	0.0001

range from .487 (Day 27) to .819 (Day 17) with an average of .679 over all thirty models. This indicates that the metamodels fail to capture about thirty percent of the variance even with blocking. This is true even for the full models where R^2 values range from .609 (Day 4) to .871 (Day 17). One suspects then that there is either high variability in the logistics processes modeled by TSAR or there are other significant factors which are omitted. We do find that each daily metamodel is highly significant as indicated by the F-statistics in Table 4.10. Given that $MS_{\varepsilon(i)}$ is an unbiased estimator of the population variance, we see that these values appear to be at reasonable levels.

Residual analyses for each daily metamodel reveal no radical departures from the assumption that the error terms are normally distributed with a mean of zero. Note: This is only an observation since we cannot legitimately test for normality because the data are not independent, but are correlated because we used common random numbers within the blocks. Plots of the residuals versus the predicted values reveal no major problem areas. Test results and complete data on the residuals are found at Appendix B.

Metamodels for the Attack Case

Table 4.11 summarizes the daily metamodels for the attack case. The beta coefficients for each model are shown only when that main effect or interaction term is

Table 4.11

Attack Case -- Daily Metamodels

$\alpha = .10$

		Attrition	Fillers	ABDR	Recovery	Personnel	AIS	Spt Equip	Spares	Missiles	Fuel
DAY	INTERCEPT	A	B	C	D	E	F	G	H	J	K
1	77.7				23.9						
2	38.7		-22.9	21.9	81.2				-11.6	26.8	
3	98.0		-41.7	10.2	44.7				-33.6		
4	68.8				19.0	11.6				10.0	13.1
5	71.8				13.9	14.4		9.6		11.6	12.1
6	130.6					10.9		13.6		34.5	
7	121.1					10.5			25.8		13.8
8	115.8	13.7	30.7			18.9					
9	92.1	29.1	24.3			15.5		26.0			13.2
10	107.6					9.1		11.2			10.9
11	72.0	21.8	31.5					27.5	21.7		30.2
12	78.9	14.3	27.8			15.6		17.7			17.2
13	80.8	10.4	26.8					19.5			16.0
14	77.4		21.3	19.5				24.8			
15	73.2	19.2	23.0	15.7							
16	74.7		18.9					15.4			
17	77.3							23.2			
18	66.5		16.2	13.2							
19	61.4		15.1	11.5				11.4			
20	59.1	9.1						14.7			
21	55.4		21.2								
22	51.4		11.1					12.2			
23	48.0		18.2								
24	51.8							13.3			-25.0
25	38.1		11.1	11.7					9.6		
26	39.1			11.0				9.2			
27	30.7		7.1	12.4				14.8			
28	29.7		16.2	9.8				10.9			
29	32.8			10.7				11.0			
30	23.3		17.5	8.4				17.4			

Table 4.11, continued

DAY	Attrition x Fillers AB	x ABDR AC	x Recovery AD	x Personnel AE	x AIS AF	x Spt Equip AG	x Spares AH	x Missiles AJ	x Fuel AK	Fillers x ABDR BC	x Recovery BD
1											
2											
3											
4											
5										11.3	
6											
7	16.1										
8									-18.8		
9				-16.0		-15.6			-15.8		
10	11.2										
11							-14.4		-21.8		
12									-20.0		-11.6
13									-15.3		
14							-10.4				
15		-14.3							-22.7		
16											
17									-15.0		
18											
19											
20									-17.5		
21									-13.0		
22						8.7			-15.0		
23											
24											
25						8.5			-10.2		
26											
27									-8.0		
28									-6.1		
29									-7.0		
30											

Table 4.11, continued

DAY	x Personnel BE	x AIS BF	x Spt Equip BG	x Spares BH	x Missiles BJ	x Fuel BK	ABDR x Recovery CD	x Personnel CE	x AIS CF	x Spt Equip CG	x Spares CH
1											
2	8.3			35.5				9.7			
3	13.1			59.9							
4				18.[illegible]					-11.9		
5				24.1				-12.2			
6				25.0		17.9					
7			20.3								
8								-18.2			
9											
10			18.0		21.9						
11											
12				20.0							
13				13.8							
14				13.7			-13.7			-15.4	
15				16.2							
16				16.0							
17				20.7		22.8					
18				12.3			-16.5				
19				19.4				-15.8			
20				18.9		21.2		-12.9		11.3	
21	-15.0			13.8						13.2	
22	-10.2			13.5		10.3				9.5	
23	-12.6			14.4						11.8	
24				21.5		16.8		-7.5			
25				17.6				-13.8			
26				28.6				-12.2			
27				16.2		8.0		-14.9			
28			-9.8	11.9				-13.3			
29				16.2		11.4		-13.9			
30	-9.8		-9.3	14.4				-8.9			

Table 4.11, continued

DAY	ADDR x Missiles	x Fuel	Recovery x Personnel	x AIS	x Spt Equip	x Spares	x Missiles	x Fuel	Personnel x AIS	x Spt Equip	x Spares	x Missiles
	CJ	CK	DE	DF	DG	DH	DJ	DK	EF	EG	EH	EJ
1												
2	-47.3											
3	-17.7											
4										-11.8		
5												
6												
7	10.5								-14.4			
8	19.3						-11.0					
9											12.1	
10												
11	18.8		12.0		-16.1							
12	12.3								-17.7			
13												12.9
14						14.3			-9.9			18.8
15												15.1
16	10.6								-10.0			13.9
17	10.3									-14.9		13.5
18						10.4			-17.2			17.8
19												17.2
20	9.9									-11.5		20.0
21										-9.5		17.4
22										-12.9		18.1
23												13.5
24		11.8								-9.8		13.8
25												18.3
26										-9.2		19.5
27					-7.6	7.0				-10.3	6.9	18.3
28									-8.3			19.0
29					-10.3	8.0						17.0
30												15.4

Table 4.11, continued

DAY	Personnel x Fuel EK	AIS x Spt Equip FG	x Spares FH	x Missiles FJ	x Fuel FK	Spt Equip x Spares GH	x Missiles GJ	x Fuel GK	Spares x Missiles HJ	x Fuel HK	Missiles x Fuel JK
1											
2	-7.5								-11.3		
3				10.7							
4		18.6								-13.2	-13.7
5									-12.4	-12.8	
6		18.0		-21.4					-24.8		-22.2
7		13.0							-14.5	-21.4	
8								21.6			
9											
10			19.3	-20.3						-13.8	
11					10.9					-15.6	-18.6
12			11.7		15.0					-14.3	-11.6
13											-13.6
14					18.1						-15.0
15					13.9			23.1			-12.9
16					18.6						-16.3
17		-16.2			20.4			12.0	10.3	-14.3	-21.9
18			12.6		12.1		10.2	20.4		-16.8	-14.1
19		-12.0			18.9			13.3	14.0	-12.9	-17.7
20		-14.5	10.2		16.2			13.8		-12.8	-19.7
21		-10.7	10.4		13.1		9.1	21.7			-16.7
22		-12.6	11.2		11.3			13.8		-8.3	-11.0
23		-10.5	12.5		8.5			18.2		-12.0	-9.1
24		-10.9	9.7		13.4			16.0		-10.1	
25		-8.8			18.6			16.6		-16.3	-12.0
26					12.5			13.1		-11.1	-15.4
27					13.4			10.8		-12.0	-12.8
28		-9.0	11.4		17.6			12.3		-8.4	-15.1
29		-7.2			12.7			9.5		-11.5	-13.2
30		-12.1			16.2						-14.2

Table 4.11, continued

If Bi = 1 then Block i
If Bi = -1 then Block 8
Otherwise Bi = 0

DAY	B1	B2	B3	B4	B5	B6	B7
1	-10.2	3.5	-13.4	2.8	16.8	8.7	-2.6
2	-6.5	57.3	-29.4	6.0	46.6	-16.6	-35.4
3	-9.8	20.3	-23.6	28.3	7.1	63.9	-34.4
4	3.7	0.3	29.7	9.4	17.1	-12.8	-12.9
5	7.1	-22.4	53.3	4.8	-1.8	2.7	-11.8
6	-30.9	9.7	16.0	11.3	14.8	-8.5	-26.6
7	-26.7	5.3	23.0	8.5	17.4	-6.1	-37.9
8	-22.2	-0.1	14.5	5.8	14.5	-7.8	-24.9
9	-21.5	-0.5	17.5	11.5	16.2	-11.7	-31.0
10	-20.0	2.4	21.5	4.3	14.3	-6.0	-32.1
11	-16.3	-1.2	14.4	1.6	17.1	-9.1	-30.2
12	-16.9	-2.9	17.8	2.0	16.2	-8.7	-33.1
13	-18.8	3.1	15.6	6.3	13.0	-4.2	-36.7
14	-18.1	-0.5	17.0	10.3	16.2	-10.4	-37.3
15	-19.8	2.4	12.0	12.8	19.2	-10.8	-34.0
16	-22.1	0.0	11.0	10.9	18.5	-7.9	-30.9
17	-17.4	1.1	10.0	8.5	19.0	-5.5	-35.6
18	-19.9	0.5	6.7	4.7	15.0	-6.1	-26.3
19	-19.2	-2.1	10.3	7.9	17.2	-5.7	-29.1
20	-20.9	-0.9	11.1	7.6	15.0	-1.7	-27.9
21	-20.5	1.3	11.4	9.0	12.7	-4.5	-29.4
22	-18.0	-1.6	11.1	10.5	8.3	-3.3	-24.8
23	-21.1	-0.6	10.7	7.3	12.6	-4.1	-22.9
24	-18.7	-6.2	17.1	8.7	10.0	-4.3	-23.5
25	-17.3	-4.1	11.3	11.6	11.0	-4.3	-24.7
26	-19.7	-1.0	12.5	9.7	12.0	-2.5	-22.0
27	-19.3	-1.4	12.8	0.9	7.6	1.1	-22.2
28	-19.0	-0.7	10.3	6.5	7.3	2.0	-21.7
29	-17.4	-1.0	8.4	9.7	8.0	0.8	-20.1
30	-16.5	-1.7	9.6	8.2	8.3	-2.2	-17.1

significant. The beta coefficient represents the change in number of sorties flown when a factor is at the high level as opposed to the low level. While individual beta coefficients provide some insights into the importance of a main effect, we must reserve conclusions until the effects of all two-way interactions have also been included. These analyses are found in Chapter V for each main effect and its interactions. Complete regression results for each estimated metamodel are found at Appendix C.

Coefficients of multiple determination are summarized in Table 4.12. For the reduced daily models, the R^2 values range from .468 (Day 6) to .927 (Day 2) with an average of .636 over all thirty models. These R^2 values tend to be better during the period of attack but then lower than those of the no-attack case on other days. The metamodels fail to capture about thirty-five percent of the variance even with blocking. This is true even for the full models where R^2 values range from .591 (Day 6) to .942 (Day 2). One suspects then that there is either high variability in the logistics processes modeled by TSAR plus that of the attacks or there are other significant factors which are omitted. Contributing to the lower R^2 values here are the four cases of no recovery which tend to skew the results. We do find that each daily metamodel is highly significant as indicated by the F-statistics in Table 4.12. Also, the population variances, as

Table 4.12

Attack Case -- Regression Statistics

DAY	FULL MODEL R2	FULL MODEL MSE	FULL MODEL F	FULL MODEL PROB>F	REDUCED MODEL R2	REDUCED MODEL MSE	REDUCED MODEL F	REDUCED MODEL PROB>F
1	0.746	162.09	3.07	0.0001	0.712	100.28	36.75	0.0001
2	0.942	361.14	17.13	0.0001	0.927	271.77	77.16	0.0001
3	0.019	915.66	4.74	0.0001	0.788	621.40	27.82	0.0001
4	0.721	507.34	2.71	0.0001	0.619	409.51	10.50	0.0001
5	0.703	785.98	2.48	0.0002	0.616	599.76	10.4	0.0001
6	0.591	1342.08	1.52	0.0490	0.468	1024.26	6.09	0.0001
7	0.693	811.38	2.37	0.0004	0.548	706.20	7.85	0.0001
8	0.617	1065.10	1.69	0.0190	0.469	856.49	6.60	0.0001
9	0.661	849.74	2.05	0.0024	0.538	677.84	8.09	0.0001
10	0.649	943.44	1.94	0.0046	0.526	745.38	7.71	0.0001
11	0.710	759.07	2.56	0.0001	0.629	588.76	9.08	0.0001
12	0.726	694.91	2.78	0.0001	0.670	512.64	10.25	0.0001
13	0.710	721.05	2.56	0.0001	0.620	548.25	12.16	0.0001
14	0.706	740.75	2.52	0.0001	0.633	556.94	9.82	0.0001
15	0.684	804.65	2.27	0.0006	0.622	569.74	10.63	0.0001
16	0.724	595.43	2.76	0.0001	0.607	492.83	11.53	0.0001
17	0.699	686.80	2.43	0.0001	0.636	503.50	9.63	0.0001
18	0.693	627.71	2.36	0.000[illegible]	0.618	474.40	8.64	0.0001
19	0.685	661.02	2.28	0.0006	0.605	498.89	8.70	0.0001
20	0.717	534.75	2.66	0.0001	0.669	391.74	9.12	0.0001
21	0.743	463.69	3.03	0.0001	0.687	342.75	11.74	0.0001
22	0.736	386.36	2.92	0.0001	0.673	299.24	9.30	0.0001
23	0.689	467.14	2.32	0.0005	0.590	367.01	8.73	0.0001
24	0.736	398.61	2.93	0.0001	0.666	306.24	10.68	0.0001
25	0.735	384.55	2.91	0.0001	0.667	293.77	10.70	0.0001
26	0.710	388.74	2.56	0.0001	0.625	297.02	10.76	0.0001
27	0.775	272.49	3.60	0.0001	0.724	208.61	11.86	0.0001
28	0.725	318.30	2.76	0.0001	0.669	237.02	9.64	0.0001
29	0.705	289.47	2.51	0.0002	0.643	215.01	9.10	0.0001
30	0.708	259.29	2.54	0.0001	0.633	194.13	10.47	0.0001

estimated by $MS_{\varepsilon*(i)}$ and $MS_{\varepsilon(i)}$, appear to be higher than in the no-attack case.

Residual analyses for each daily metamodel reveal no radical departures from the assumption that the error terms are normally distributed with a mean of zero. As noted above, the test for normality is not legitimate since the data are correlated. Residuals plotted against the predicted values reveal no major problem areas. Test results are summarized in Table 4.10. Complete data on the residuals are found at Appendix D.

The Impact of Attacks

The research objective here is to determine whether attacks on the air base cause a significant difference in flying performance. Before any statistical tests are done, an informal visual comparison of the daily metamodels for both cases (see Tables 4.9 and 4.11) reveals that each day's models for the two cases not only have different values for the beta coefficients, but often do not even contain the same significant factors and/or interaction terms. Thus it appears that there is a difference in the two cases that can be attributed to the attacks. Below we test for significant differences in the mean response between the two cases and develop confidence intervals for the differences.

Since sorties flown are not independently and identically distributed at each design point, valid statistical comparisons or tests for differences must be restricted to individual design points. Differences between the two cases can be tested as developed in Chapter III based on Student's t-distribu-tion. From (3.23) and (3.24) we have our hypotheses for testing the difference between the mean number of sorties flown on Day i with attacks, $\mu_k^*(i)$, and the mean number of sorties flown on Day i without attacks, $\mu_k(i)$, at a design point k:

$$H_0: \quad \mu_k^*(i) = \mu_k(i)$$

$$H_1: \quad \mu_k^*(i) < \mu_k(i)$$

These hypotheses are tested at two design points, (a) all factors at the high level and (b) all factors at the low level, for each Day i = 1, 5, 30. Test results are shown in Table 4.13.

The results indicate significant differences in the mean response for the attack and no-attack cases at 5 of the 6 design point-day combinations tested. The only point where no difference is detected is Day 30 when all factors are at the high level. It appears that any difference caused by the attack (as indicated by the results for Days 1 and 5) have subsided by the end of the 30-day period when all factors are high. As noted in Chapter III, this test is conservative so that the 5 cases where we detect significant differences at $\alpha = .05$ are really significant at a even lower level.

Table 4.13

Tests for Significant Impact of Attacks

	$\underset{\sim}{x}_k[\hat{\underset{\sim}{\beta}}^*(i)-\underset{\sim}{\beta}(i)]$	$t_{(.05,v_{eff})}$ (v_{eff})	t_0	DECISION
DESIGN POINT (a)				
Day 1	-157.8	-1.6551 (168)	-21.6300	reject H_0
Day 5	-84.7	-1.6551 (168)	-4.6204	reject H_0
Day 30	+1.0	-1.6525 (214)	+0.0691	accept H_0
DESIGN POINT (b)				
Day 1	-186.0	-1.6551 (168)	-25.4955	reject H_0
Day 5	-105.4	-1.6551 (168)	-5.7496	reject H_0
Day 30	-39.6	-1.6525 (214)	-2.7364	reject H_0

From (3.33) we also compute a conservative 95% confidence intervals for the differences $(\mu_k^*(i) - \mu_k(i))$ which are shown in Table 4.14. These confidence intervals are plotted in Figure 4.5 and support the conclusions drawn above concerning significant differences in daily sortie counts attributable to attacks. In Figure 4.5 we see that the confidence interval for Day 30 differences when all factors are high spans zero. This leads to the conclusion that there is no significant difference attributable to attacks in this case. We also note no great differences between the confidence intervals for the two design points suggesting that the impact of attacks overshadows any difference caused by resource level.

Overall, we conclude that attacks do make an impact on the number of daily sorties flown. However, this impact seems to dissipate as time passes. These results are consistent with what we would expect given the destruction and disruption caused by attacks on an air base.

Table 4.14

Confidence Intervals for Differences Attributed to Attacks

	$t_{(.975,v_{eff})}$ (v_{eff})	LOWER (Sorties)	$\underset{\sim}{x}_k[\hat{\underset{\sim}{\beta}}^*(i)-\hat{\underset{\sim}{\beta}}(i)]$	UPPER (Sorties
<u>DESIGN POINT (a)</u>				
Day 1	1.9759 (168)	-172.2	-157.8	-143.4
Day 5	1.9759 (168)	-120.9	-84.7	-48.5
Day 30	1.9719 (214)	-27.5	+1.0	+29.5
<u>DESIGN POINT (b)</u>				
Day 1	1.9759 (168)	-200.4	-186.0	-171.6
Day 5	1.9759 (168)	-141.6	-105.4	-69.2
Day 30	1.9719 (214)	-68.1	-39.6	-11.1

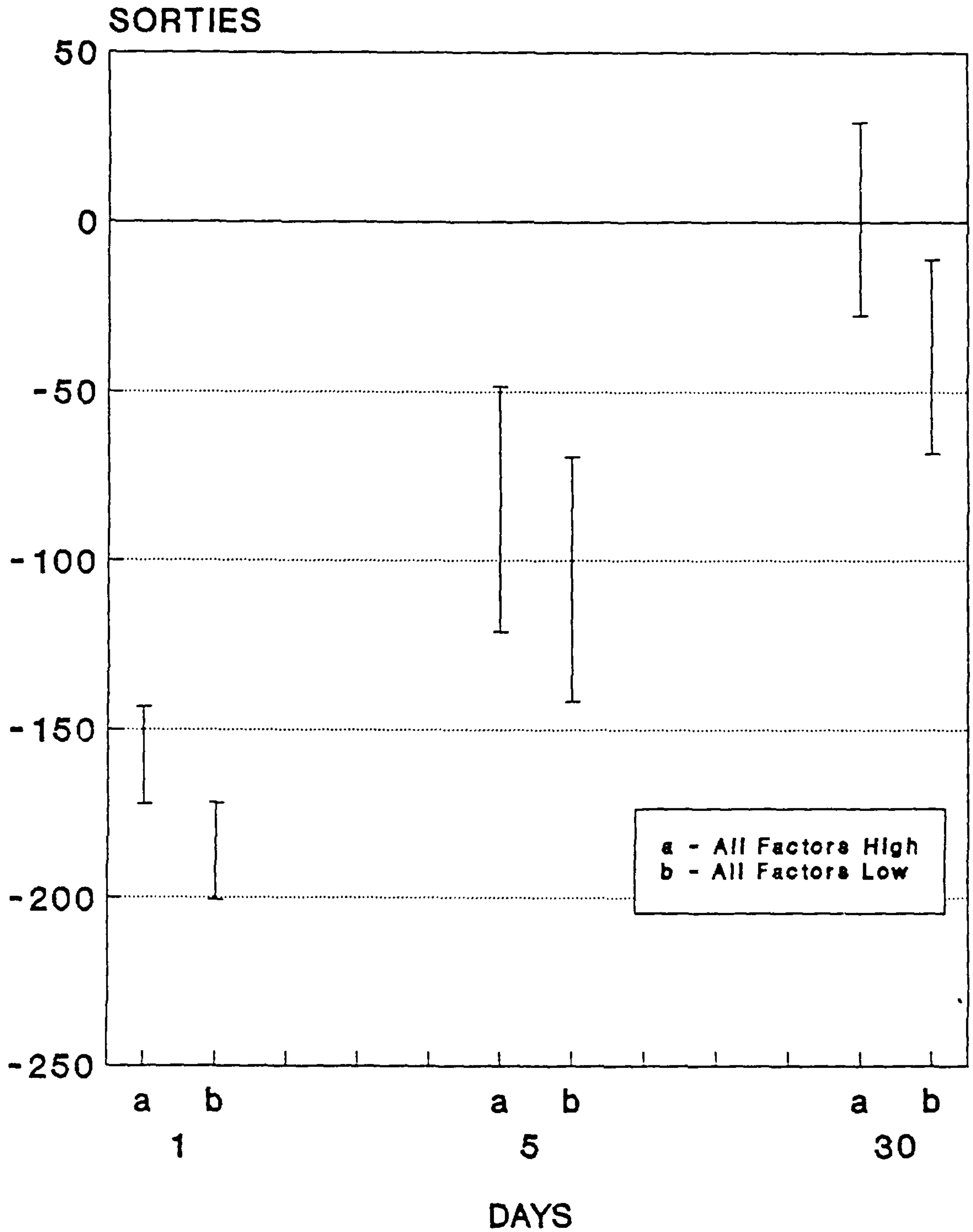


Figure 4.5

Confidence Intervals for Differences Attributed to Attacks

CHAPTER V - INTERPRETATION OF THE METAMODELS

This chapter addresses the estimated metamodels and compares results for the two cases, attack and no-attack. First we discuss overall general results for the no-attack case as compared to the attack case. Next we focus on the significant factors and interactions for the no-attack case. Similarly, the attack case is then presented. Lastly we look at each factor's contribution to sortie generation with and without air base attack.

Overall Comparison of the No-Attack and Attack Cases

One would expect attacks on an air base to make a difference in the number of sorties flown. Besides damage to runways and taxiways which prevent aircraft from taking off, resources are destroyed, people are injured and killed, utilities such as water and electricity are lost, and a generally chaotic atmosphere endures until operations are restored to normal. Below we will examine various combinations of attack/no-attack and high/low resource levels in order to better understand the overall influence of attacks on the number of expected daily sorties flown.

Attack Versus No-Attack

As discussed above, the experimental design was applied to an attack scenario and repeated with a no-attack scenario. Here we compare overall results for the two experiments focusing on the effect of the attack on similar resource postures.

All Factors Low. As can be seen in Figure 5.1, when all resource levels are low, more sorties are flown in the absence of attacks then when the base is attacked. The plotted lines are based on the estimated daily metamodels with all resources at the low level. The lines are nearly congruent from Day 6 on with an approximate difference of 40-50 sorties per day on average. During the attack period (Days 1-5), the difference between the two lines is especially significant. Figure 5.2 shows the expected differences between the two cases. Thus it appears that the attacks reduce the capability of the logistics infrastructure to produce sorties when all resources are at the low level.

All Factors High. When all factors are at the high level, the gap between the attack and no-attack cases closes to about 30 sorties per day after the attacks stop on Day 5 (see Figures 5.3 and 5.4). Again there are large differences during the attack period. On Day 27 the lines actually cross with the attack case flying more sorties per day. Whether this trend would continue after Day 30 is unknown.

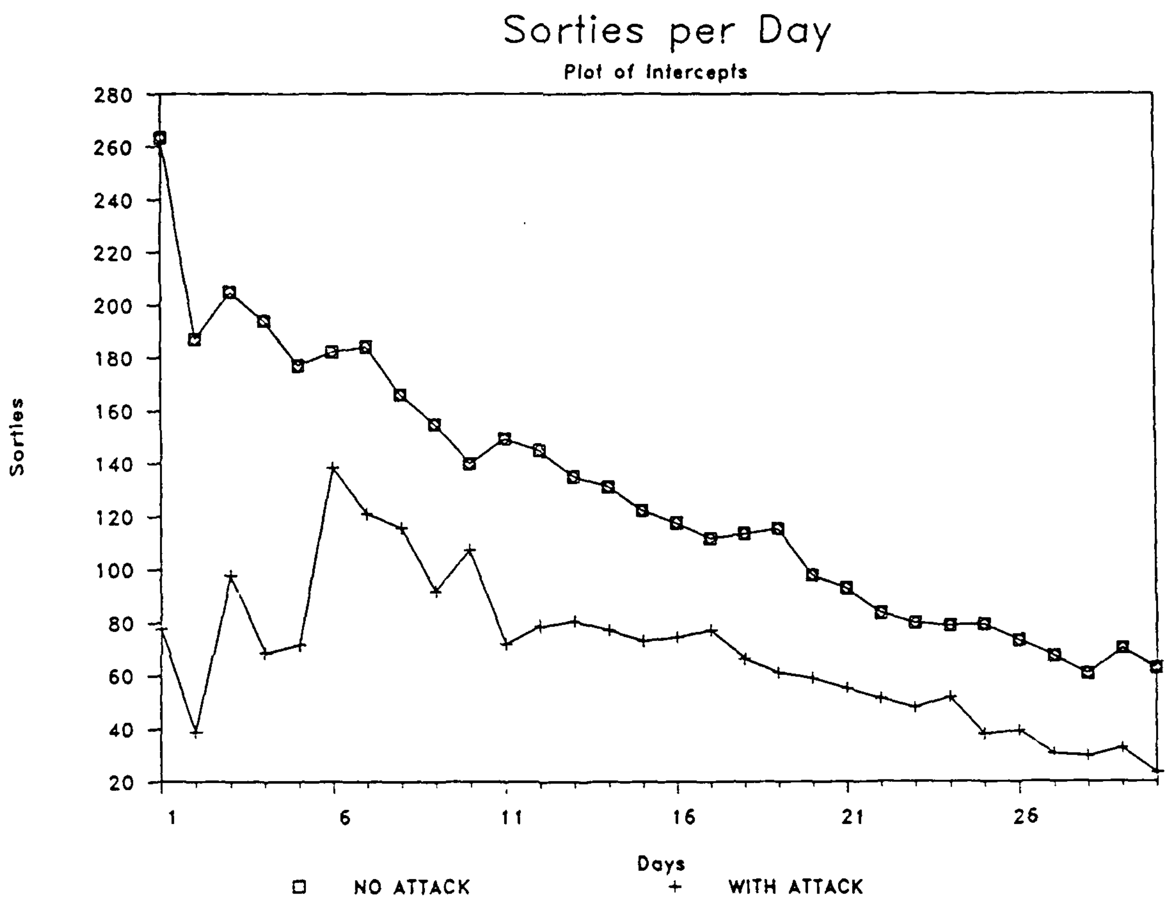


Figure 5.1

Sorties Per Day with All Factors Low

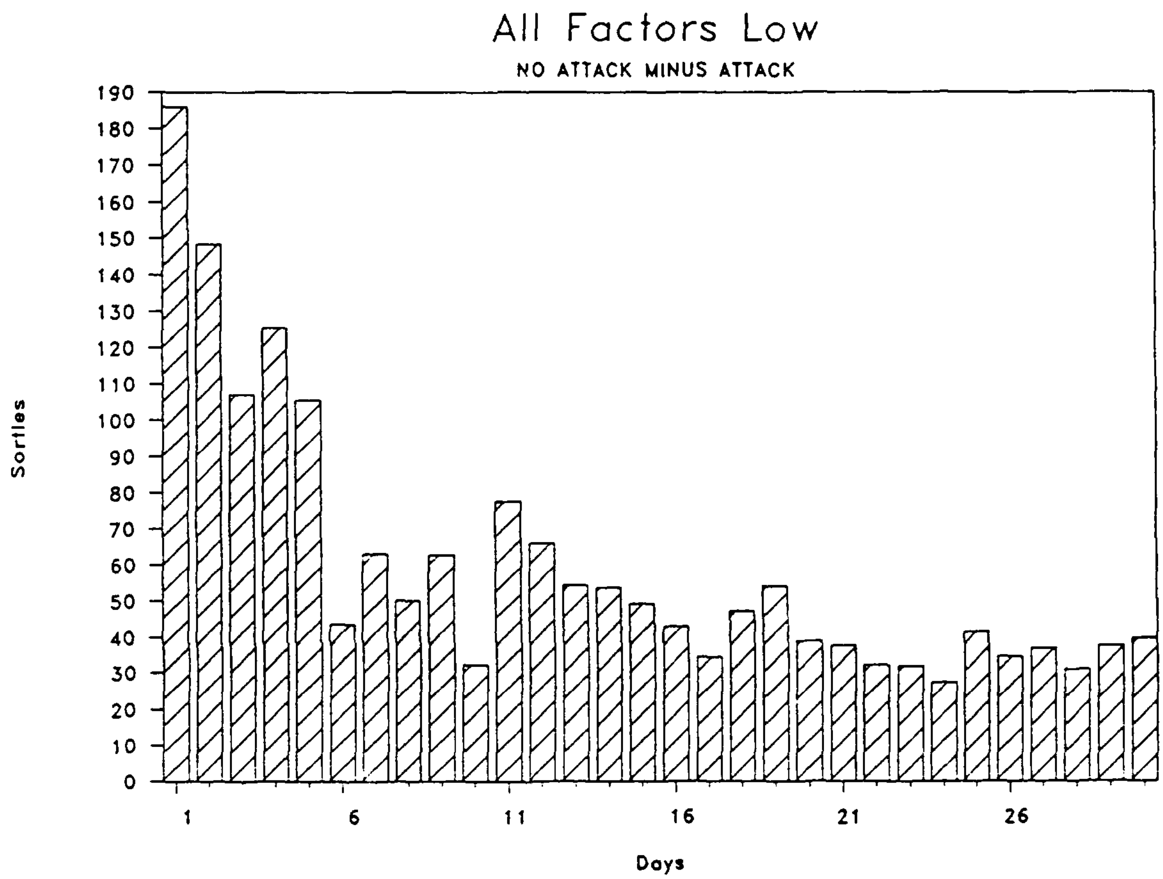


Figure 5.2

Difference Between Attack and No-Attack Cases with All Factors Low

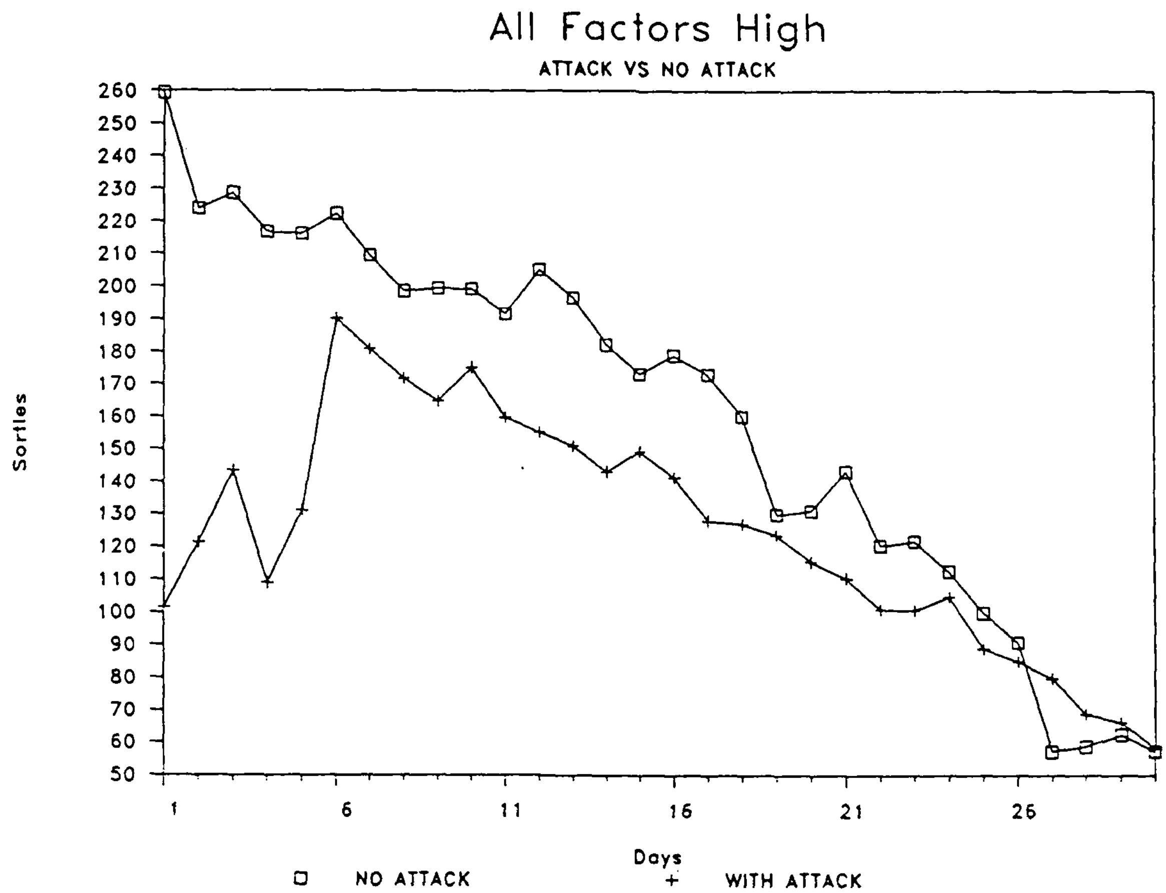


Figure 5.3

Sorties Per Day with All Factors High

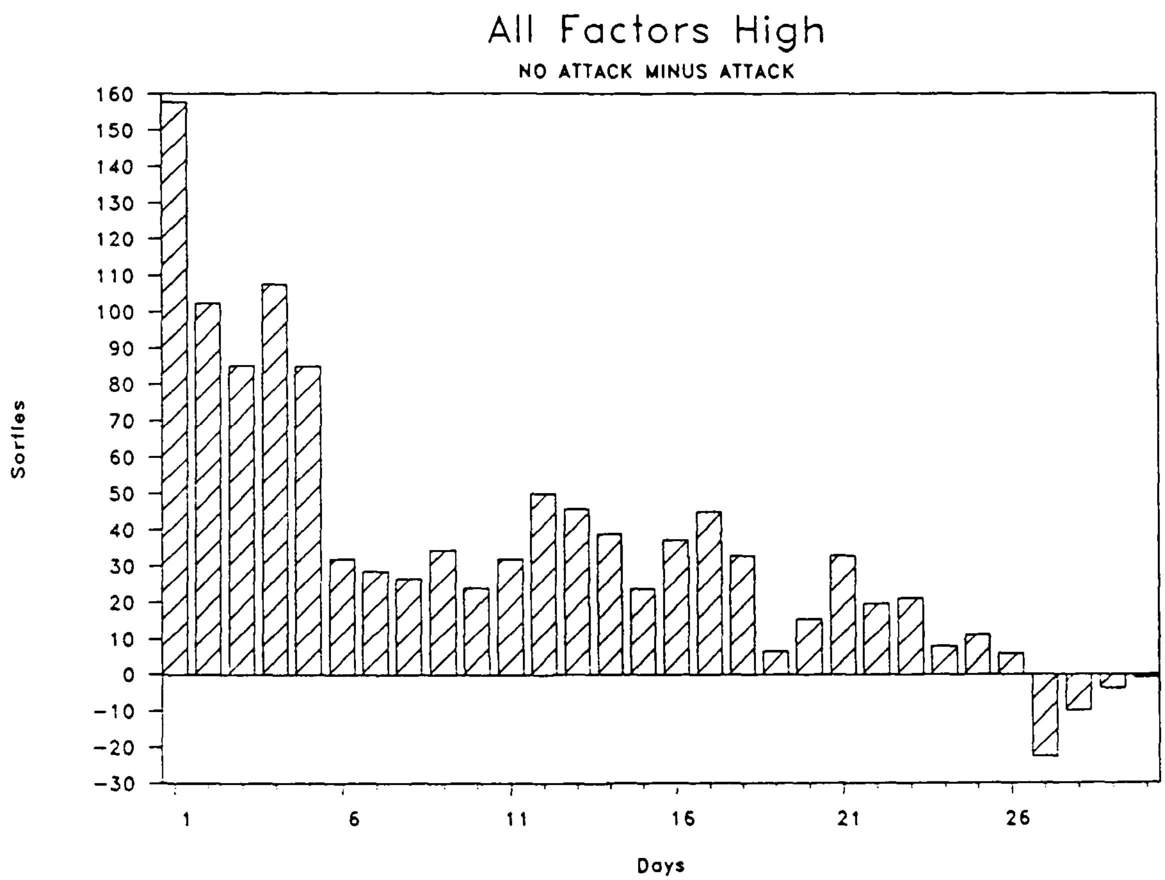


Figure 5.4

Difference Between Attack and No-Attack Cases with All Factors High

Generally, when we have high factor levels without attack, many more sorties are flown which also means that more aircraft are lost (based on a rate per sortie flown) and expendable resources are consumed faster. As a result fewer aircraft are available to fly in the later days as compared to the attack case where fewer sorties were flown initially (and therefore fewer losses). From the resource consumption point of view, fewer sorties can be supported during the later days because of the depletion of consumable stocks such as missiles and fuel. With attacks, the resource pools do not draw down as quickly because the attacks delay flying and hence consumption of resources.

All Factors High Versus All Factors Low

Here we examine the influence of resource postures separately by scenario.

No-Attack Case. Figure 5.5 depicts the comparison of the different resource postures over time in the absence of attacks. Here we see a definite difference on Day 2 which remains until Day 27. The differences during the attack period, however, are not as great as those seen above when similar resource levels were compared with attacks as the variable effect. The lines actually cross on Day 27 and the "all low factor" case begins to fly more sorties per day, albeit small differences. Figure 5.6 portrays the levels of the daily differences.

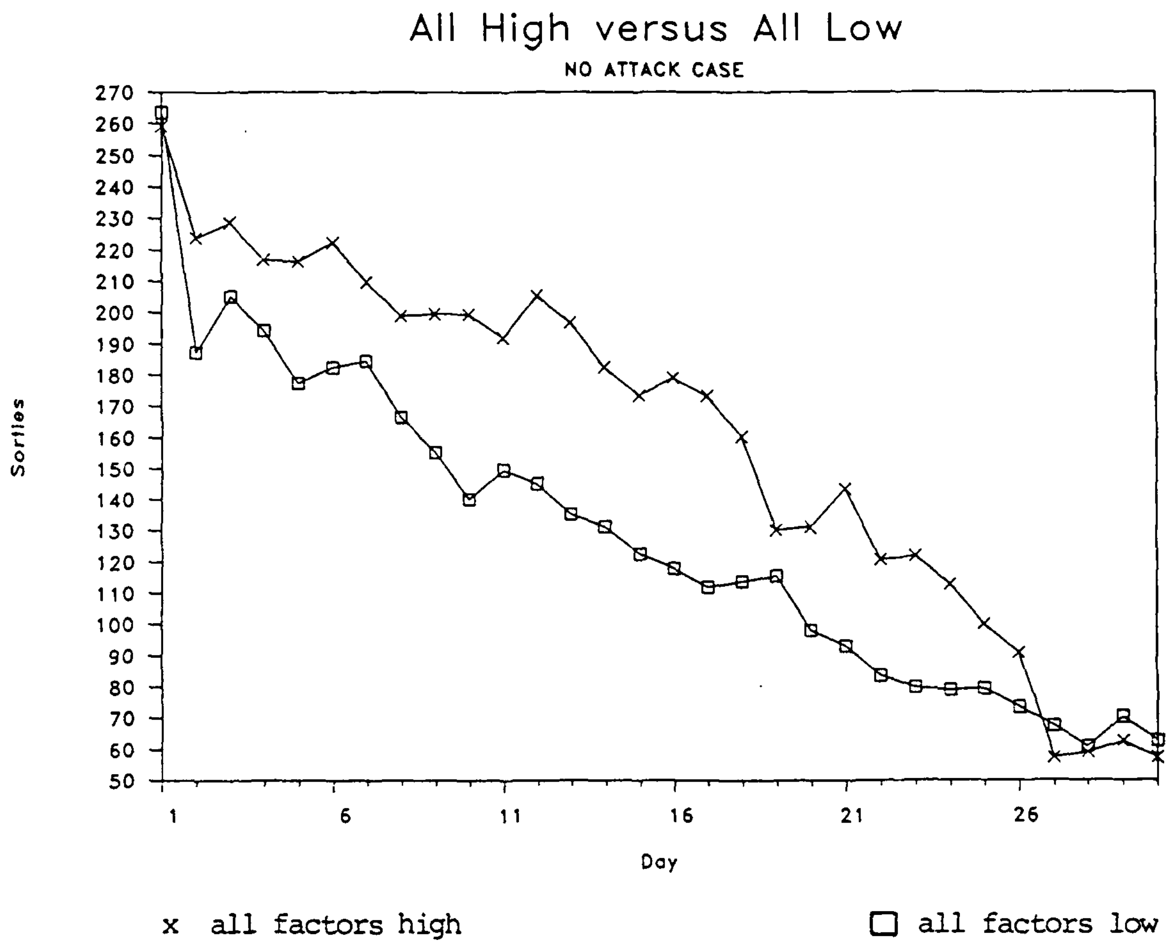


Figure 5.5

No-Attack Case -- All Factors High Versus All Factors Low

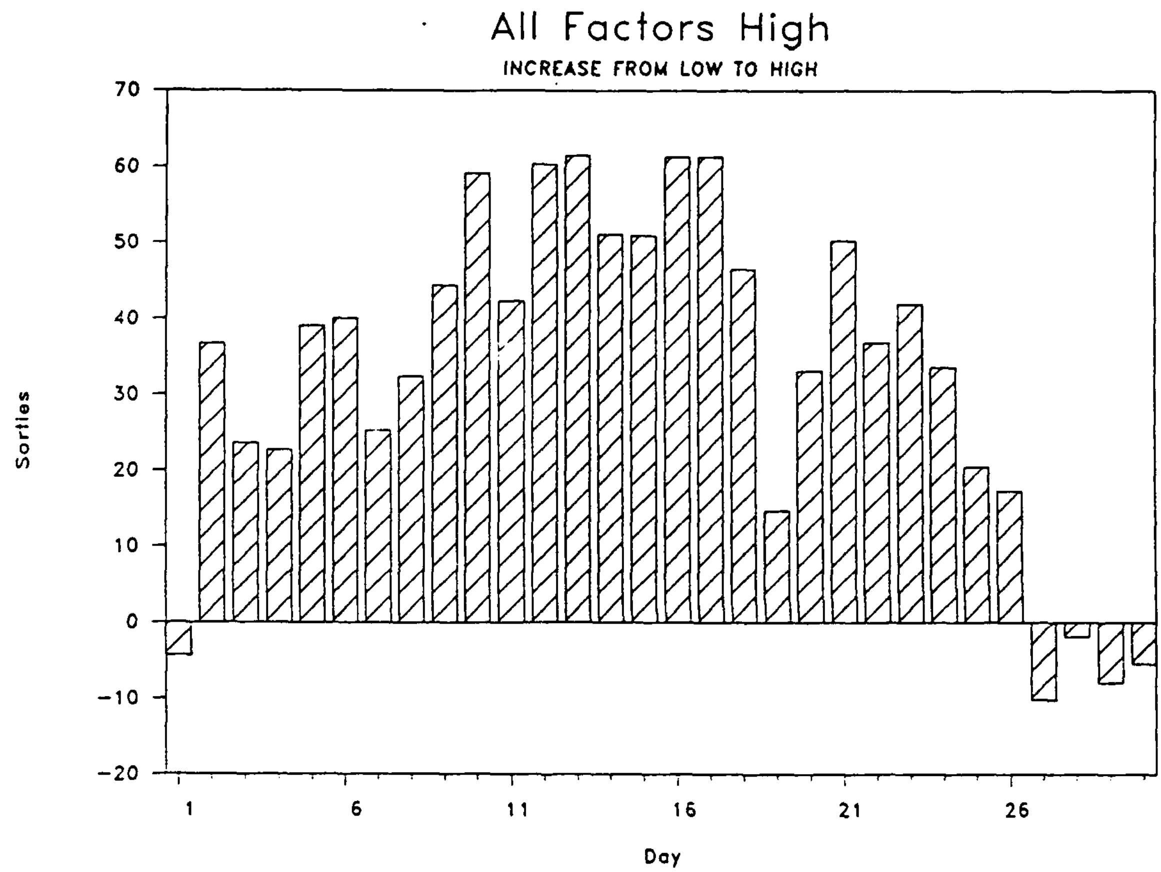


Figure 5.6

No-Attack Case -- Difference Between All Factors High and All Factors Low

With Attack Case. In Figure 5.7 we see that the two postures yield different, but nearly congruent results when attacks are present. Differences in expected daily sorties flown are shown in Figure 5.8. It appears that the attacks have a similar effect on sorties flown and the factor levels determine the level of sortie generation attained.

Summary: All Factors High Versus All Factors Low and Attack Versus No-Attack

Figure 5.9 depicts the four cases discussed above. High factor levels appear to outperform low factor levels given similar attack conditions. Results for the "all high - attack" case are actually better than the "all low - attack" case after the attacks stop on Day 5. Thus it appears that high resource levels are desirable whether or not attacks are expected. From Day 6 on, all the lines are fairly congruent and decline linearly in the number of sorties flown per day. The "all low - attack" case seems to provide a lower bound while the "all high - no-attack" case, for the most part, provides an upper bound. The two remaining cases, "all low - no-attack" and "all high - attack" are very similar after the attack period.

No-Attack Case Factor Results

Overall results for the no-attack case are shown in Table 4.8 which depicts the daily metamodels found by stepwise regression. Entries in the table are the beta

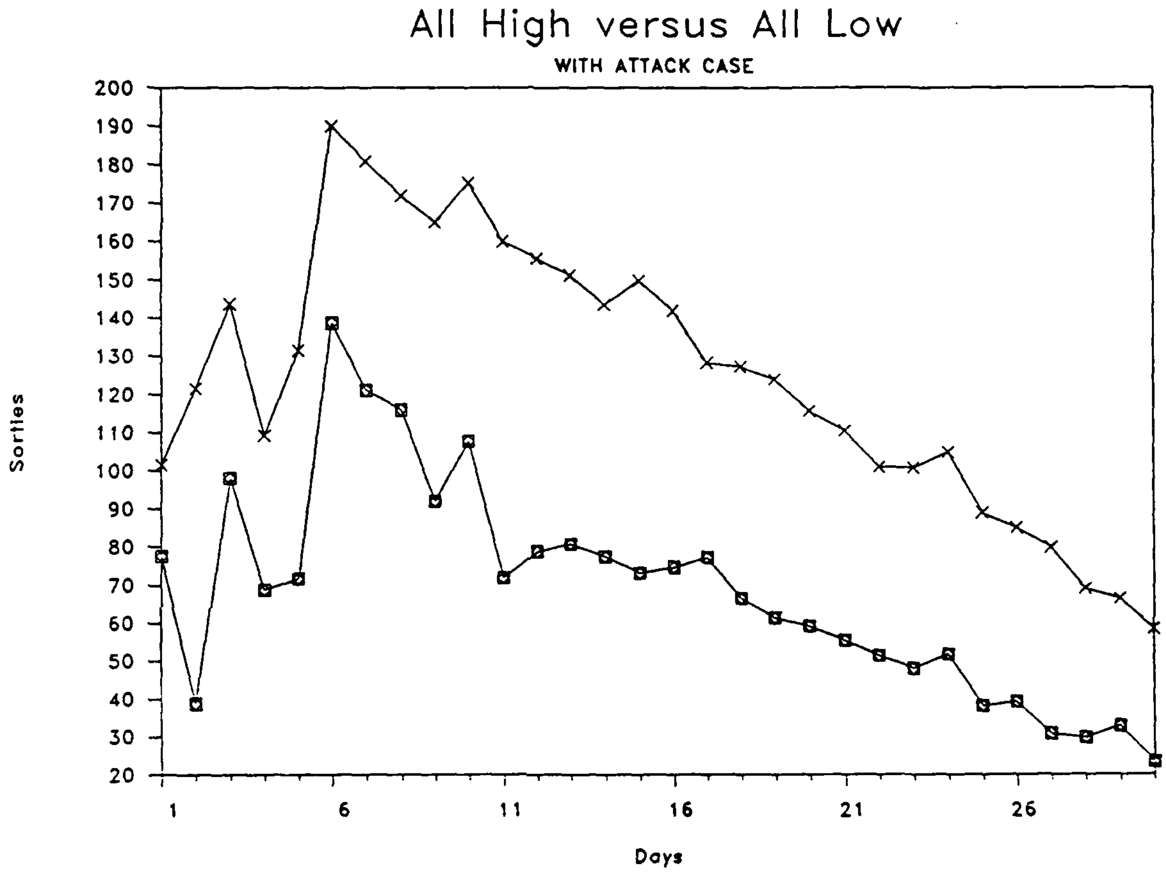


Figure 5.7

Attack Case -- All Factors High Versus All Factors Low

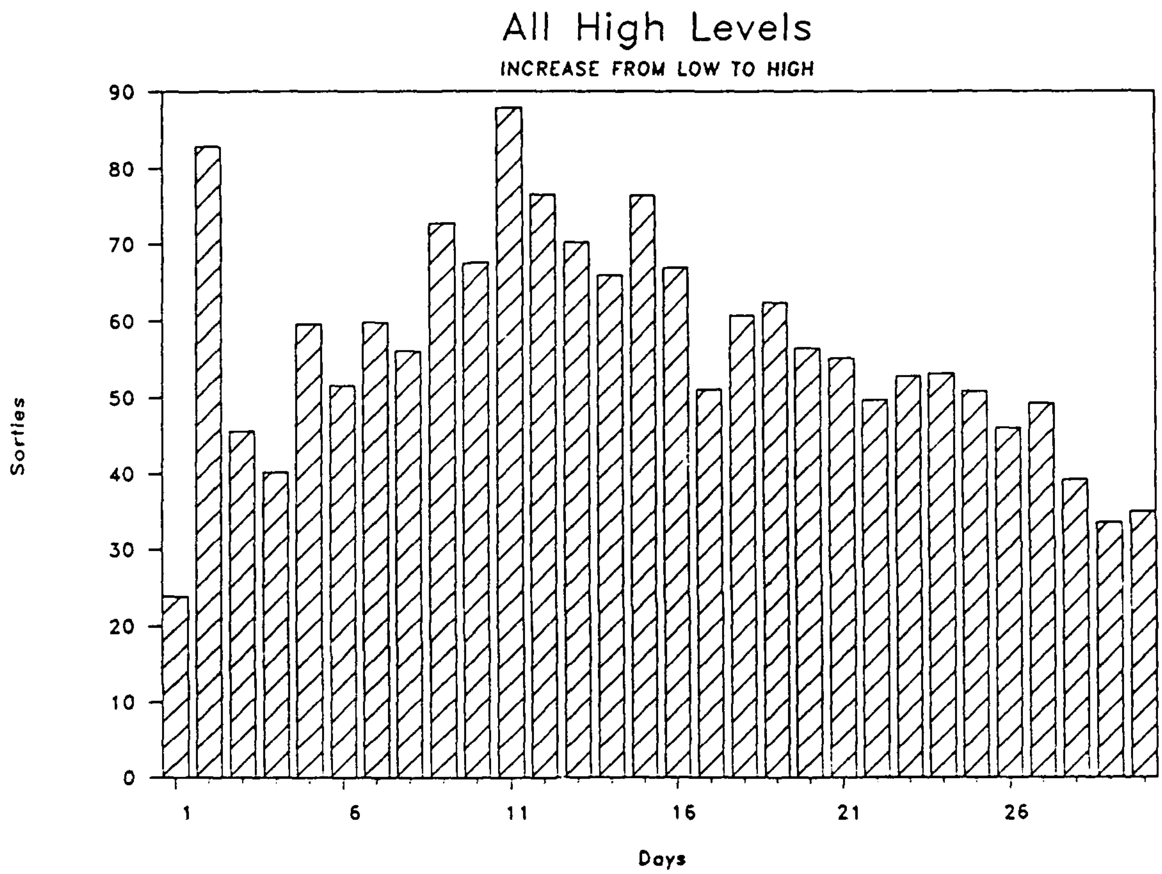


Figure 5.8

Attack Case -- Difference Between All Factors High and All Factors Low

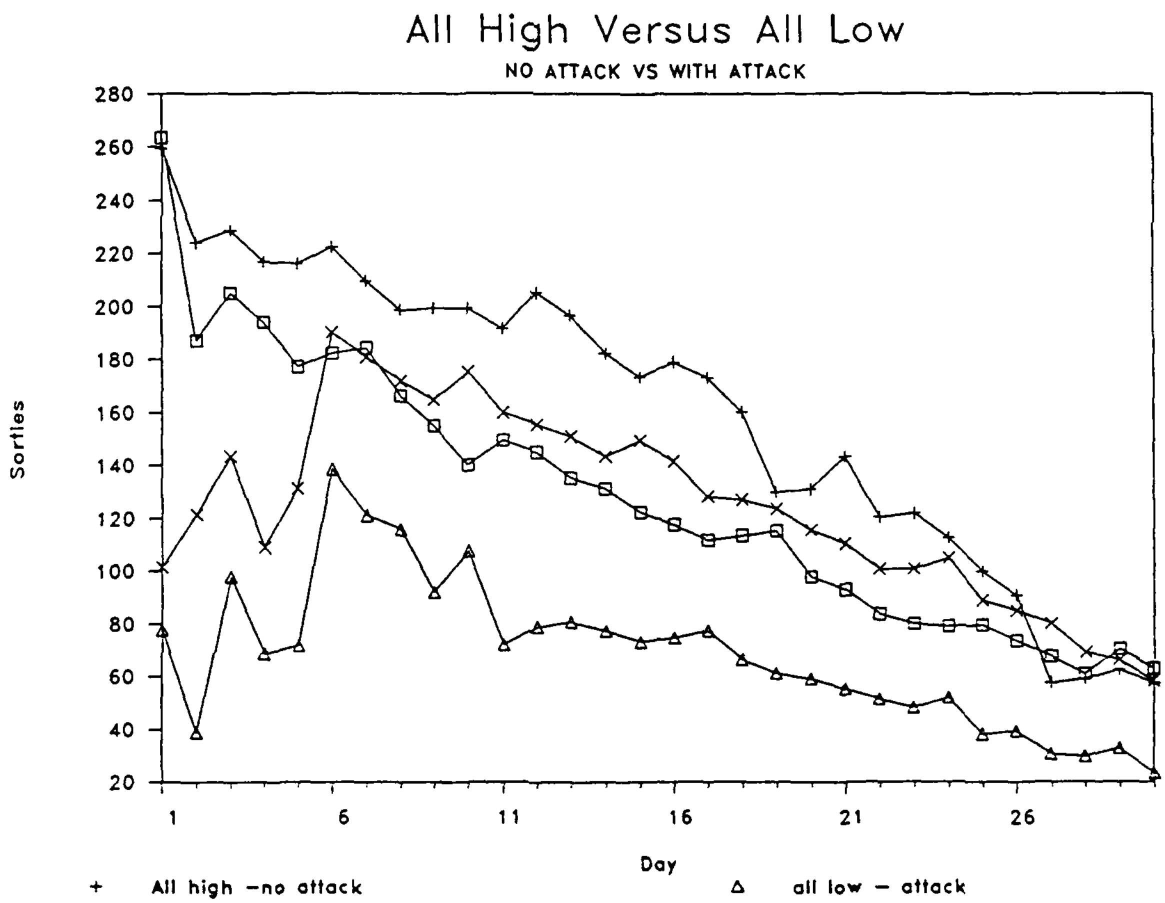


Figure 5.9

Comparison of Four Resource-Attack Combinations coefficients of the factors that were significant in each daily model. The beta coefficient represents the change in number of sorties flown when a factor is at the high level as opposed to the low level.

Table 4.8 also provides a visual picture of which factors tend to be significant and when. For example, looking at main effects only, we see Filler or Replacement Aircraft are significant factors in many of the daily metamodels. Other main factors which appear to be significant over time are Personnel, Spare Parts, Missiles, Fuel, and ABDR. The remaining main effects are significant at various times, but appear more sporadically. Figures 5.10 and 5.11 depict the beta coefficients of these main effects when they are significant factors in the daily metamodels. As seen in the figures, some contributions are positive while others are negative. Below we examine those main effects which tend to have significant beta coefficients over time along with the most significant two-way interactions.

Main Effect: Filler or Replacement Aircraft

As seen in Figure 5.10, Fillers contribute positively to sorties flown in most of the daily metamodels. This is especially true in Days 10-26 where additional sorties per day are as high as 44. However, negative coefficients are found in the models for Days 28-30. These could represent the cost of flying earlier, perhaps an added strain on the

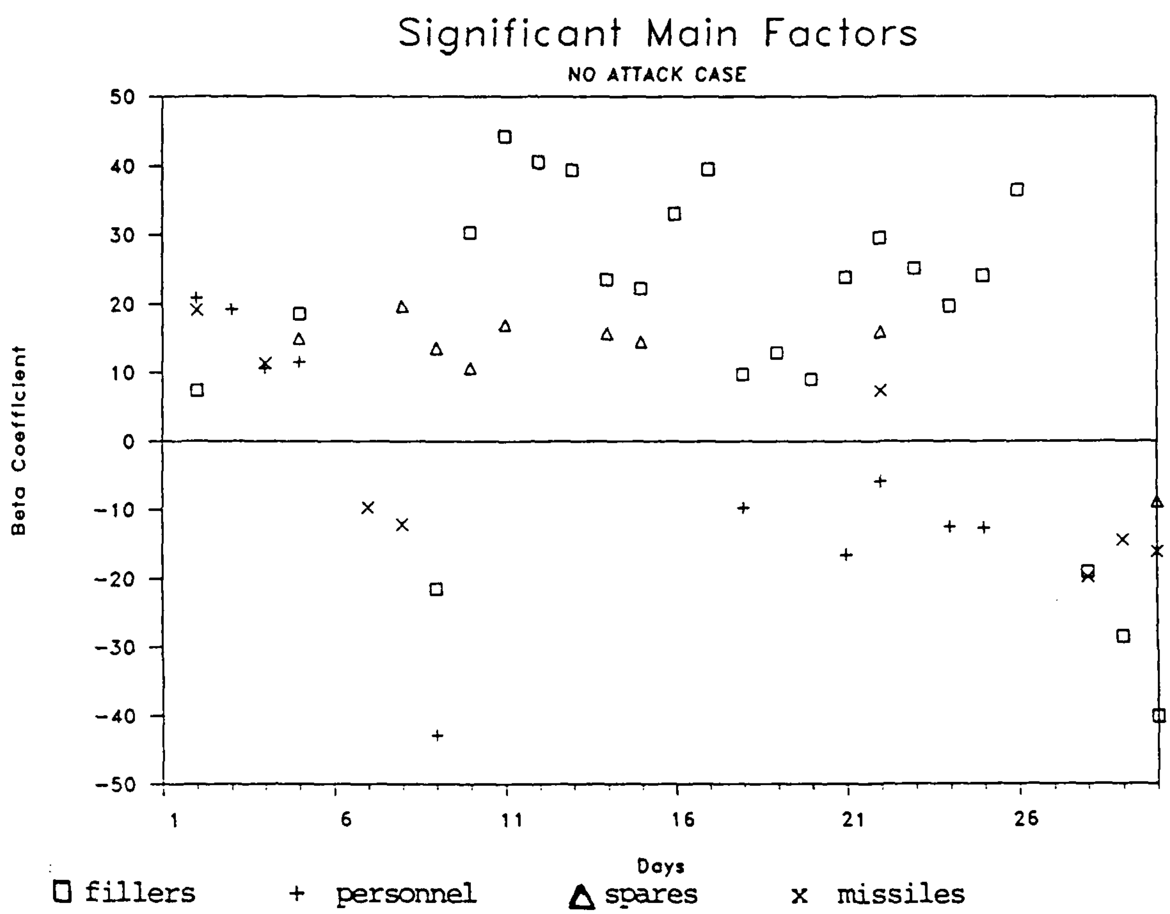


Figure 5.10

No-Attack Case -- Significant Main Factors (1)

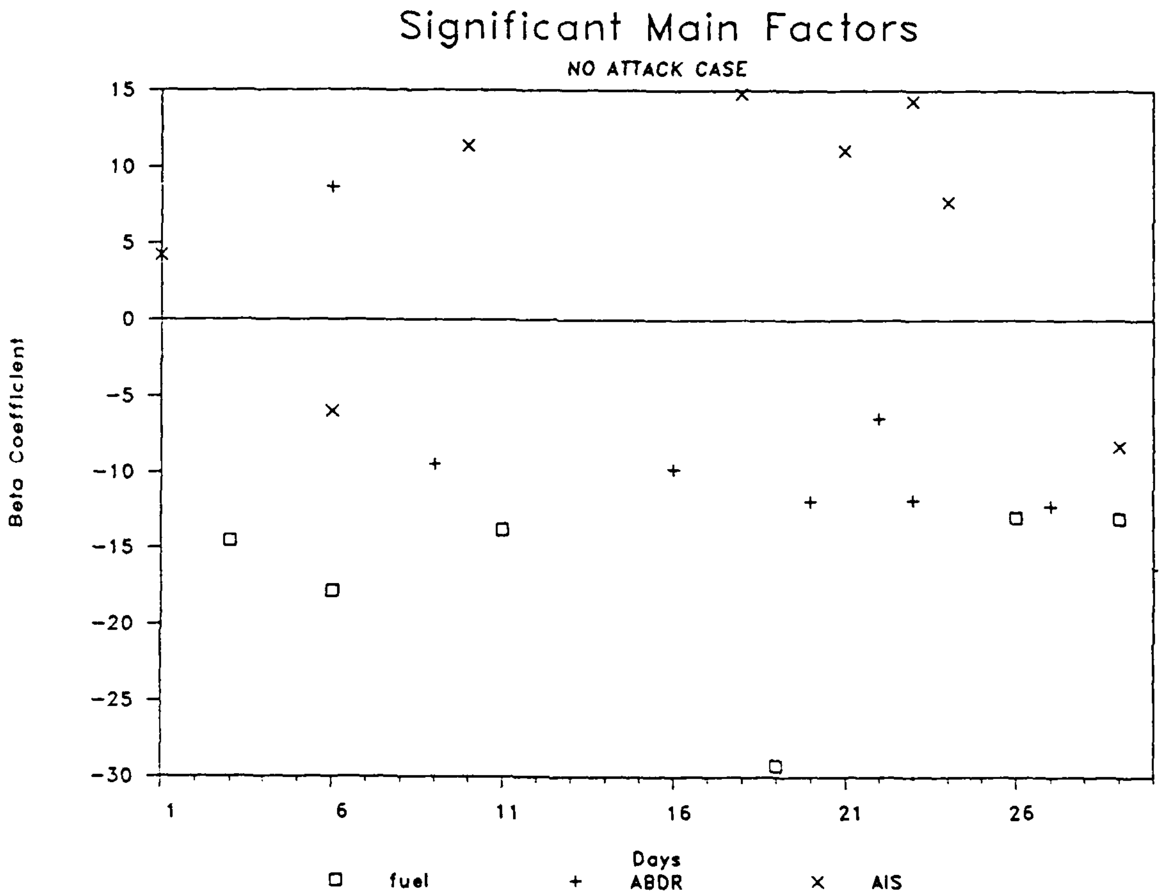


Figure 5.11

No-Attack Case -- Significant Main Factors (2) resources available resulting in quicker resource consumption and finally inability to support these added aircraft in the later days. Fillers also appear to have important two-way interactions with several other main effects: ABDR, Spares, Fuel, and Missiles.

<u>Filler x ABDR interactions</u>, shown in Figure 5.12, are mostly positive and significant after the second week. It appears that increased ABDR capability allows damaged aircraft to be returned to flying sooner and, along with extra aircraft available as fillers, the result is more sorties flown. Note that the coefficients are negative for Days 28 and 29. This may be a "cost" resulting from flying in earlier days. Figure 2.2 is helpful for understanding this non-intuitive result. Increased ABDR and Fillers lead to more aircraft available and more sorties can be flown. However, more sorties flown also means more aircraft losses to attrition; thus over time the benefits are offset and can result in less sorties flown in later time periods.

<u>Filler x Spare Parts interactions</u> are shown in Figure 5.12 and generally follow the same pattern as the Filler x ABDR interaction: some positive coefficients in the middle time frame, with what again appears to be a cost (in the form of negative coefficients) in the last five days. Apparently the combination of fillers (i.e. more aircraft) plus enough parts to keep them flying results in more aircraft losses

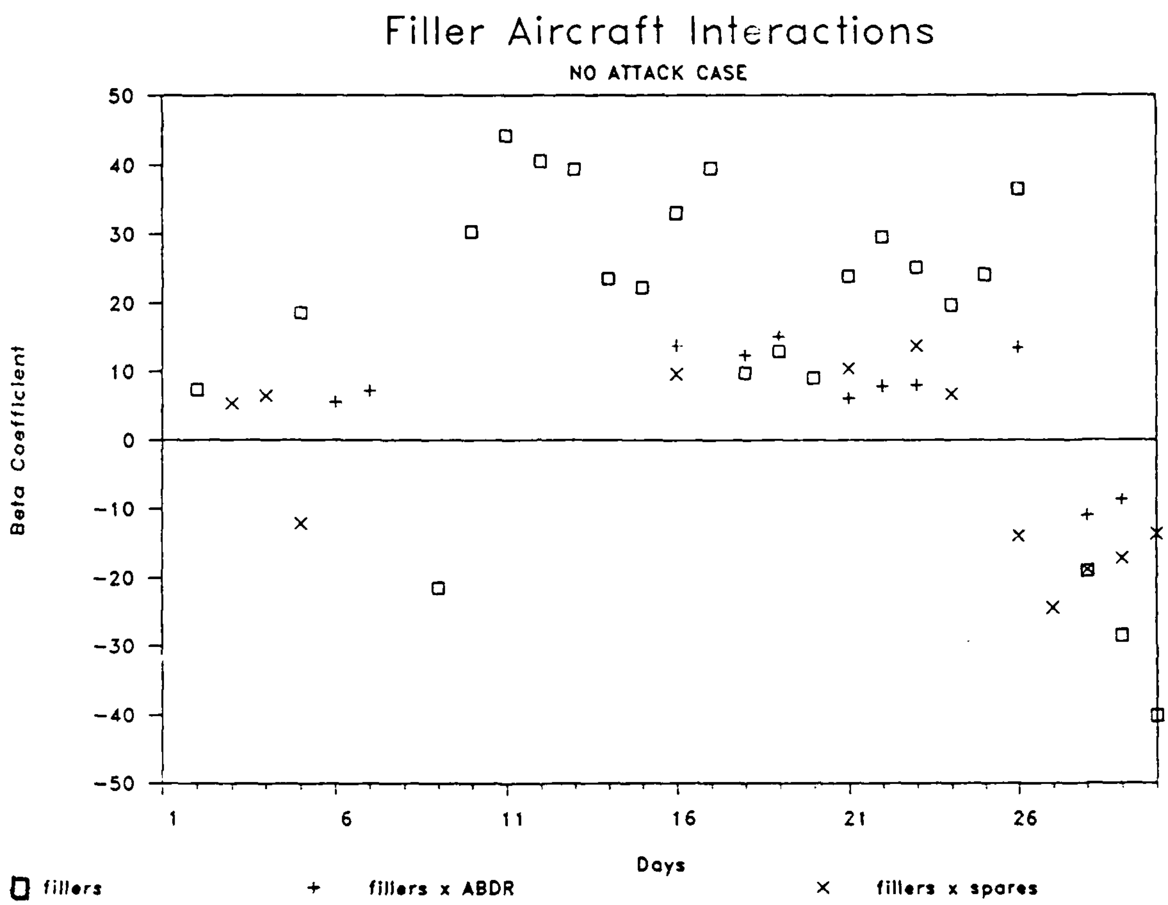


Figure 5.12

No-Attack Case -- Filler Aircraft Interactions (1) earlier and fewer aircraft are left for the later days than if those additional resources had not been available.

Filler x Fuel interactions, shown in Figure 5.13, have alternating positive and negative effects in the first and third weeks, and then large positive contributions in the last four days -- over 40 sorties per day for the last three days. The occurrences of positive coefficients seem to precede occurrences of negative coefficients, suggesting a small-scale trade-off of flying early at the expense of flying the next day or two. The large positive contributions in the last four days mean that the extra filler aircraft lead to more sorties in the final days only when fuel resources are also available to support them.

Fillers x Missiles interactions, shown in Figure 5.13, are similar to the Filler x Fuel interactions except that we see notable positive contributions to flying in weeks one and two. Apparently, the extra missiles allow more of the additional aircraft to fly needed sorties; without missiles, the aircraft will not be sent into combat.

Net Effect and Summary. Figure 5.14 shows that the net effect of having the high level of Fillers, as opposed to the low level, is very positive. Figure 5.14 is derived by using the estimated daily metamodels to predict the differences in sorties flown when Fillers are at the low level and all other factors are high as compared to sorties flown when all factors are high. Interactions are also taken into account

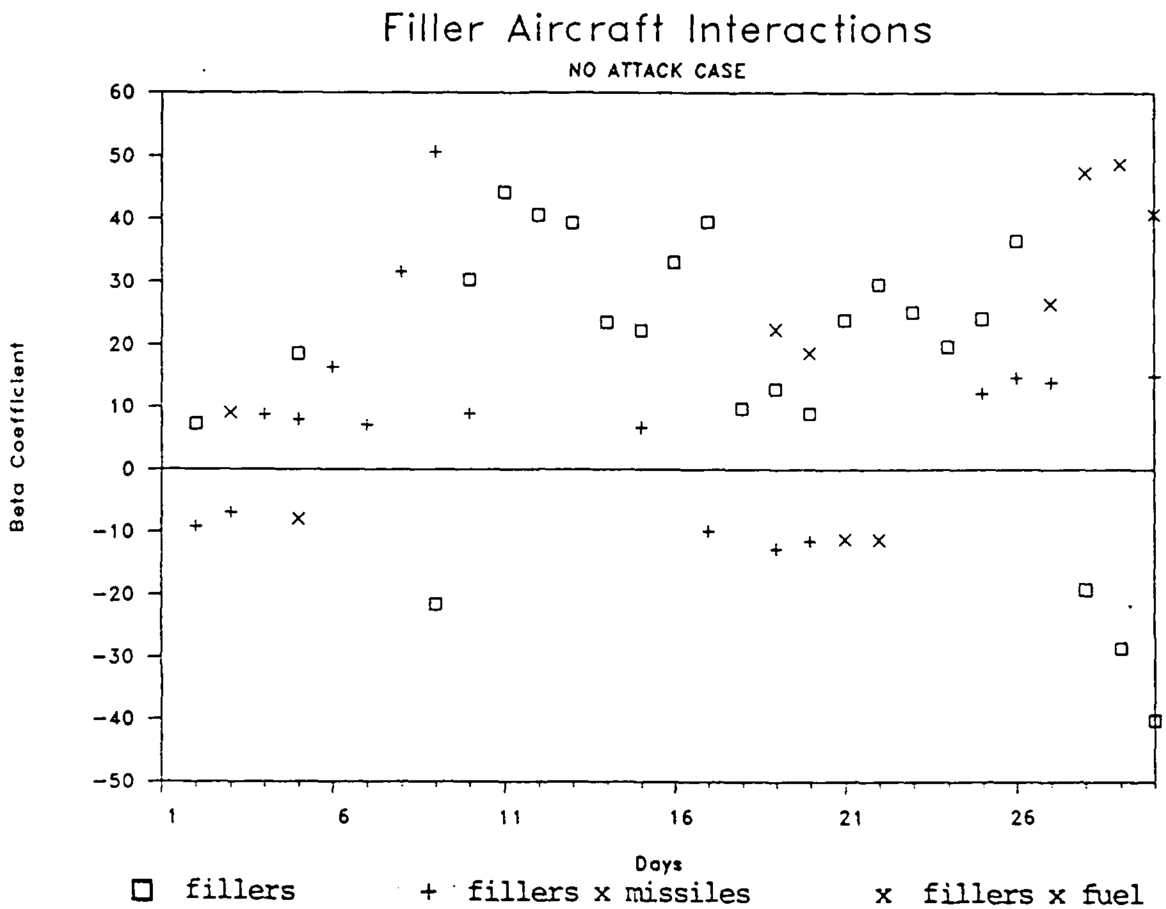


Figure 5.13

No-Attack Case -- Filler Aircraft Interactions (2)

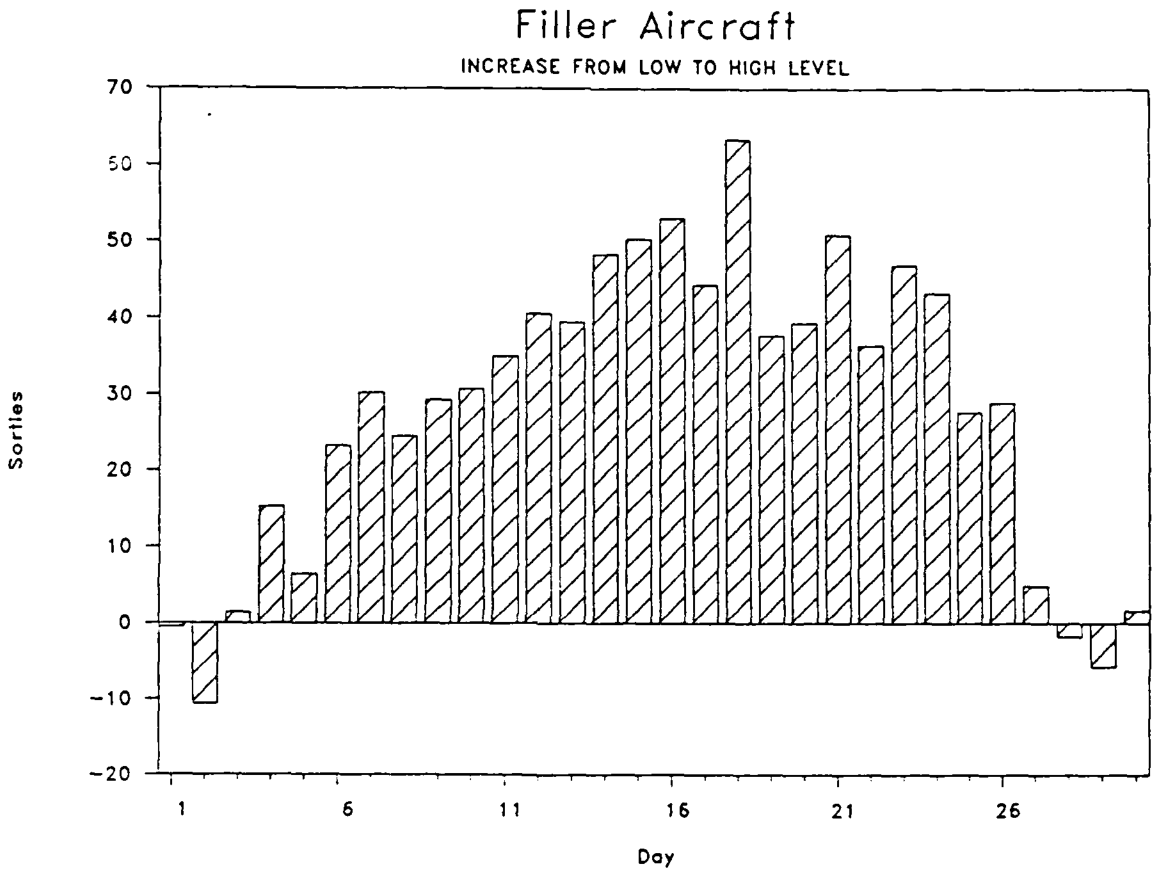


Figure 5.14

No-Attack Case -- Overall Contribution of Filler Aircraft and the corresponding coefficients for Filler interactions drop out when Fillers are low. Overall, Fillers or replacement aircraft are beneficial, but we also need to be able to support them with missiles, spares, and fuel to realize their full sortie potential. Also, early additional flying may result in negative coefficients in later metamodels. This may be acceptable when early sorties might have more bearing on the outcome of the war than later sorties.

Main Effect: Personnel

The contributions of the Personnel main effect are shown in Figure 5.10 along with the other important main effects. Personnel show significant early contributions where the demands for flying are highest. Because more people are available to fix and service aircraft, more planes are ready to fly sooner. But we also see a negative impact after Day 17, an apparent cost resulting from the early benefits of having a high level of Personnel. Referring to Figure 2.2, more people lead to more flyable aircraft which in turn lead to more sorties flown. More sorties flown means more resources are consumed and/or more aircraft are attrited and thus less aircraft are available to fly later. Personnel also appears to have important two-way interactions with Missiles and ABDR.

Personnel x Missiles interactions, shown in Figure 5.15, contribute large quantities of daily sorties (15 to 59) to the flying effort during Days 7-10. Then Days 16-20 have negative coefficients. People are important in the assembly of delivered missile components. Having high levels of both people and missiles potentially allows more aircraft to be armed and flown with missiles. Negative contributions are most likely due to the earlier additional flying enabled by the Personnel x Missiles interaction where additional aircraft are attrited and thus not available later as they would otherwise have been.

Personnel x ABDR interactions show steady positive contributions, mostly in the middle time periods (see Figure 5.15). The high level of ABDR allows battle-damaged aircraft to begin repair sooner, while the high level of maintenance people allows the aircraft to be made flyable quicker. Since the nature of the ABDR process is generally long, the contributions of this interaction appear later in the time periods.

Net Effect and Summary. Some areas in the logistics infrastructure rely heavily on manpower, such as we see above with missile assembly and ABDR processes. Contributions tend to be positive when high personnel levels are combined with the needed resources in such labor-intensive processes. Figure 5.16 portrays a positive net effect of personnel in the first 18 days, but also highlights the resulting negative

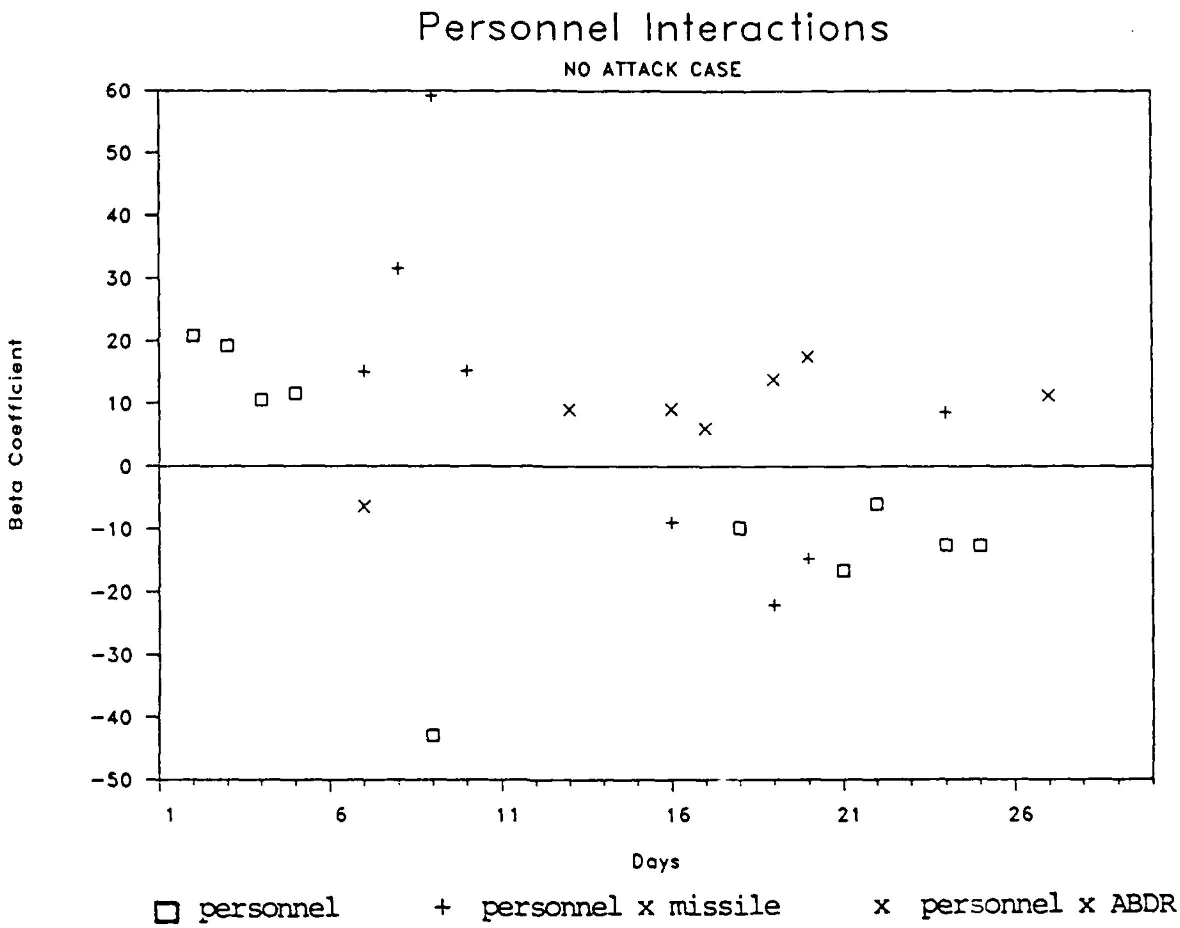


Figure 5.15

No-Attack Case -- Personnel Interactions

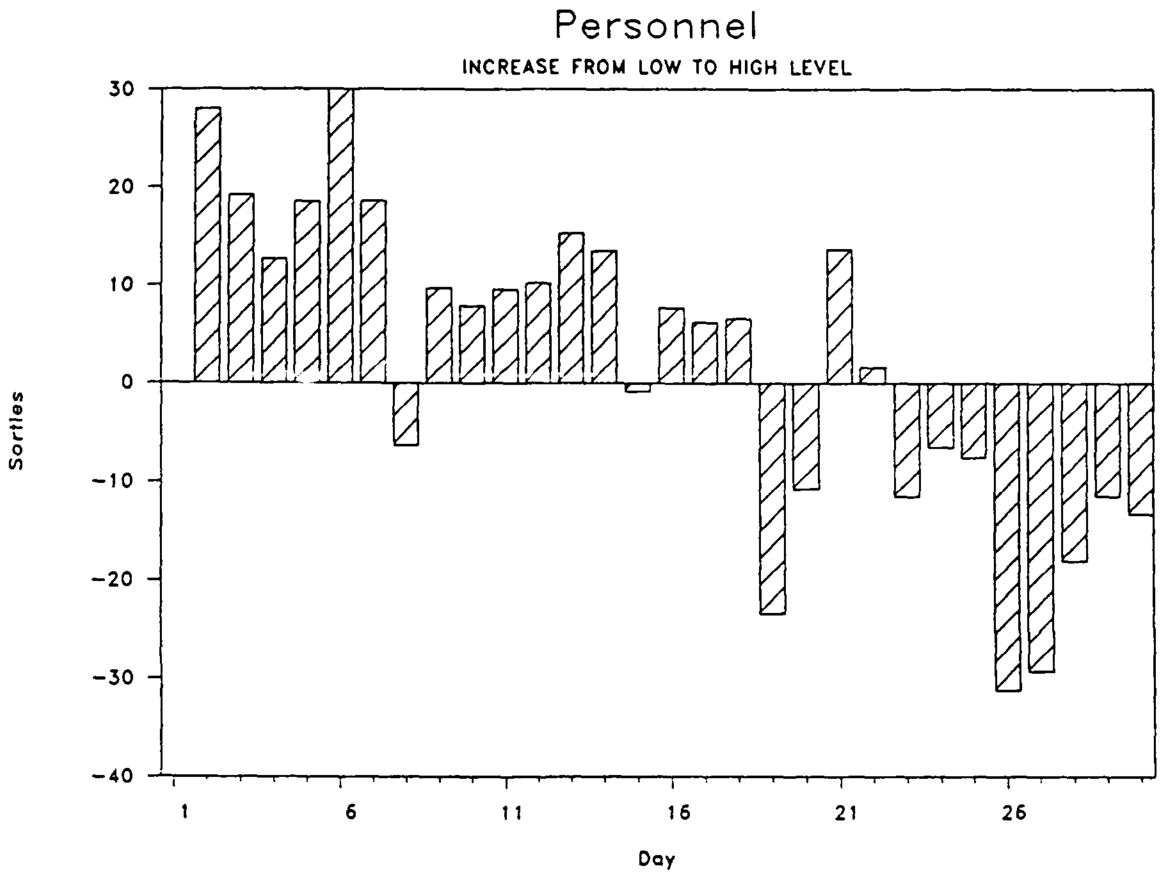


Figure 5.16

No-Attack Case -- Overall Contribution of Personnel impact felt in the later days. There are several sporadic two-way interactions with personnel that have negative coefficients in the later time periods. These will not be discussed since the pattern over time is not significant, but the coefficients can be seen in Table 4.8. The negatives do offset some of the positive gains of the personnel interactions in the first 18 days. Again, the early benefits may outweigh the later costs if the early flying has more bearing on the outcome of the war than the later sorties.

Main Effect: Spare Parts

The contribution of Spares is almost entirely positive and found in the second week (see Figure 5.10). Overall this seems to indicate that the low level of Spares is sufficient for the first week, but then more parts, as provided by the high level, would increase the number of sorties flown. Component repair backlogs might also contribute to the need in the second week, especially since Spares do not remain significant in the later daily metamodels. Spares do have some important two-way interactions with other main effects. The most notable are the interactions with Missiles, Support Equipment, and Fillers.

Spares x Missiles interactions are shown in Figure 5.17. For the most part, the coefficients are negative in the middle time frame, but during the last four days we find positive coefficients. The coefficients, representing the

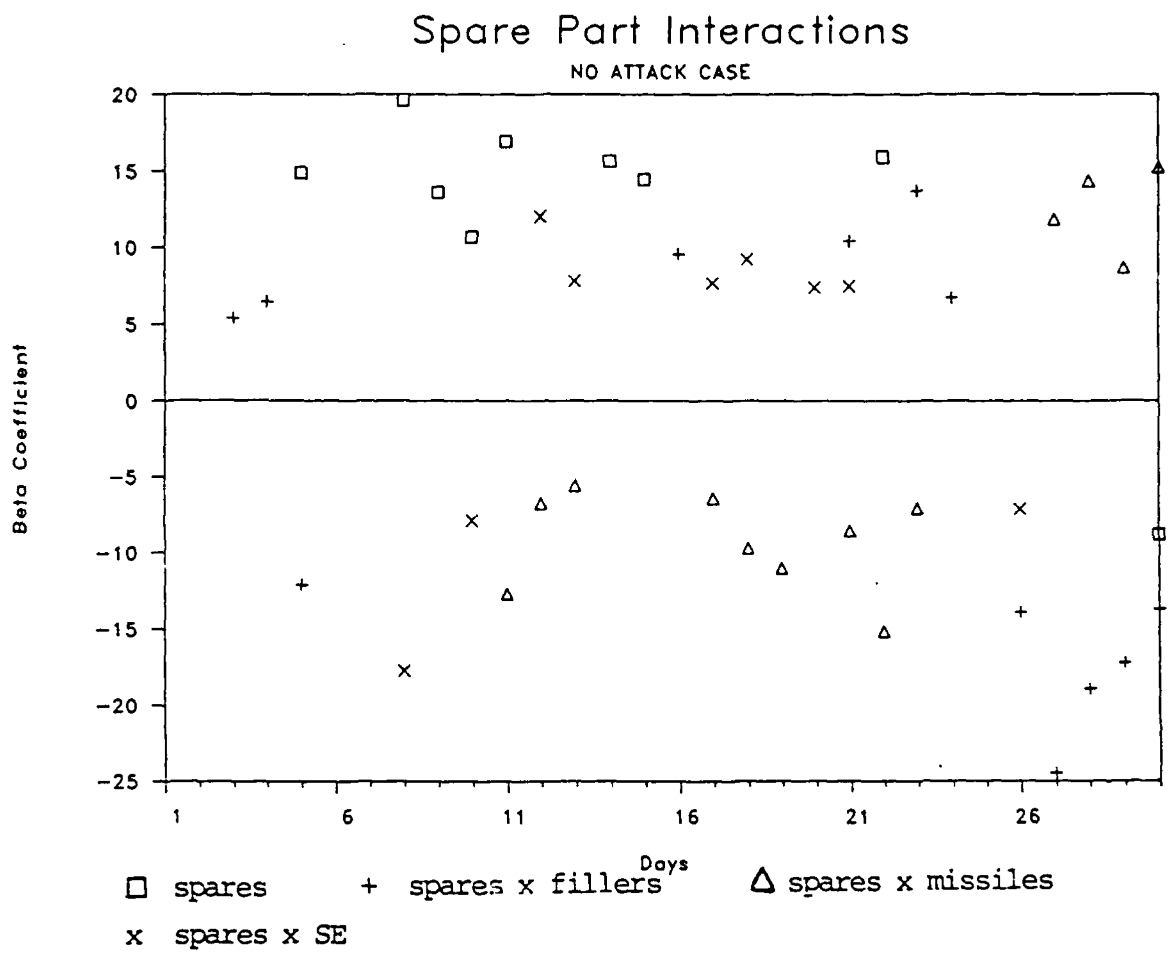


Figure 5.17

No-Attack Case -- Spare Part Interactions daily contribution to sorties flown when both Spares and Missiles are at high levels, are fairly small in magnitude. The negative contributions range from -6.4 to -15.2 sorties per day while the positive range from 8.7 to 15.3 sorties per day. The negative coefficients could result from earlier flying since increases in both spares and missiles lead to greater numbers of aircraft available to fly and hence more sorties flown and aircraft lost. Increased flying also means greater resource consumption with less available to support later flying demands. Thus there seems to be a cost for the early sorties as discussed above for other interaction terms; here, however, the cost (reflected by negative contributions) appear in the middle rather than at the end of the 30-day period. The positive contribution at the end might be a cyclic effect begun by the earlier flying. Here the lost aircraft mean fewer sorties are flown in the middle periods, and this, in turn, means less resources are consumed. As a result there are more resources per aircraft remaining and more sorties can be supported. The process appears to be cyclic with costs and benefits associated with different time periods.

Spares x Support Equipment interactions, shown in Figure 5.17, are mostly positive and occur predominantly in the middle time periods. Support equipment are necessary for many of the repairs on aircraft and their components. A high level potentially allows more aircraft to be worked on and thus use the high level of Spares available.

Spares x Filler Aircraft interactions are discussed above. Figure 5.17 shows the interaction coefficients along with the Spares main effect and other important Spares two-way interactions.

Net Effect and Summary. The availability of Spare Parts, high level versus low level, has both positive and negative effects. Figure 5.17 shows this clearly. From Figure 5.18, the net effect is cyclic, but mostly positive, especially in the middle time periods. There are notable negative contributions in the last five days which appear to be the cost of earlier flying allowed by the high resource levels.

Main Effect: Missiles

Missiles, as seen in Figure 5.10, appears to add sorties early in the flying effort, but then costs sorties later because the early "extra" flying results in additional aircraft losses and/or resource consumption and hence less flying later. Missiles has important two-way interactions with many of the other main effects.

Missiles x ABDR interactions are shown in Figure 5.19. Generally, we see negative contributions in the first 14 days. High levels of both factors ought to allow increased sorties. Increased ABDR capability makes more aircraft

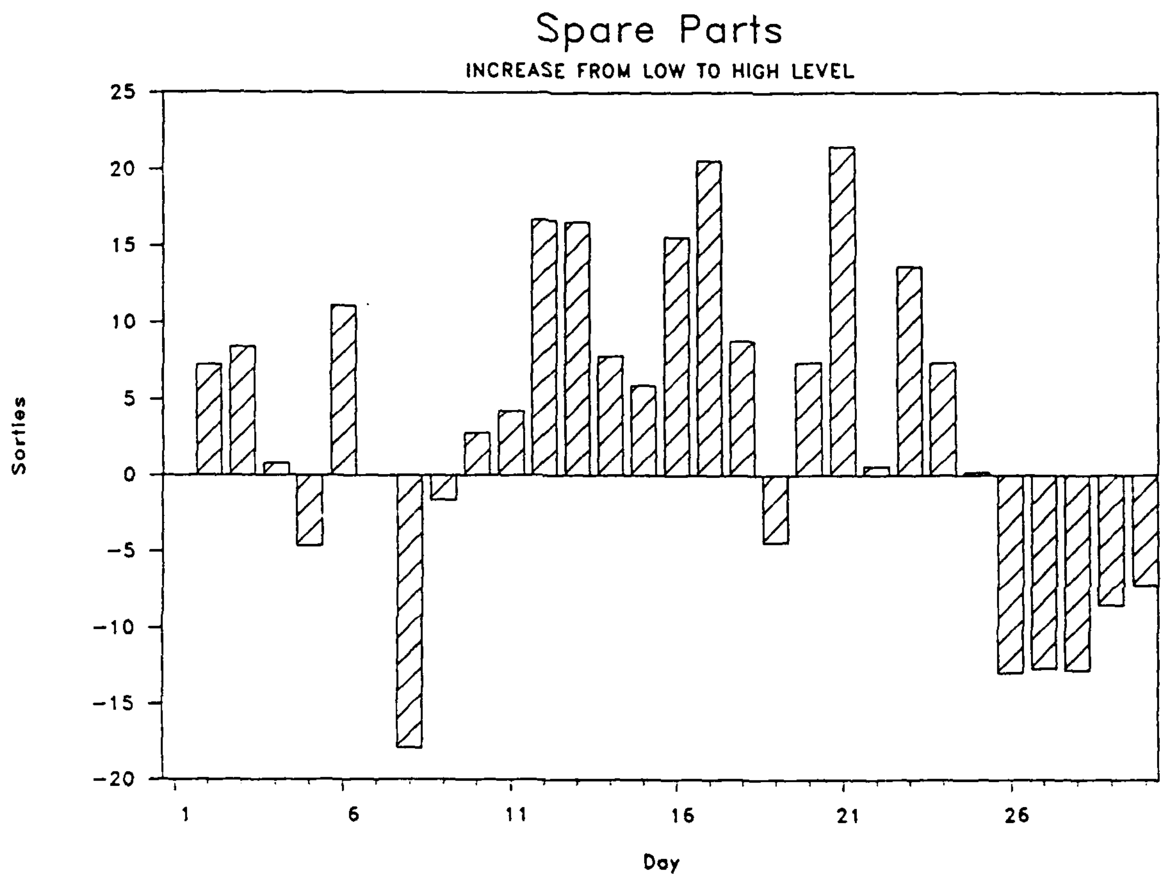


Figure 5.18

No-Attack Case -- Overall Contribution of Spare Parts

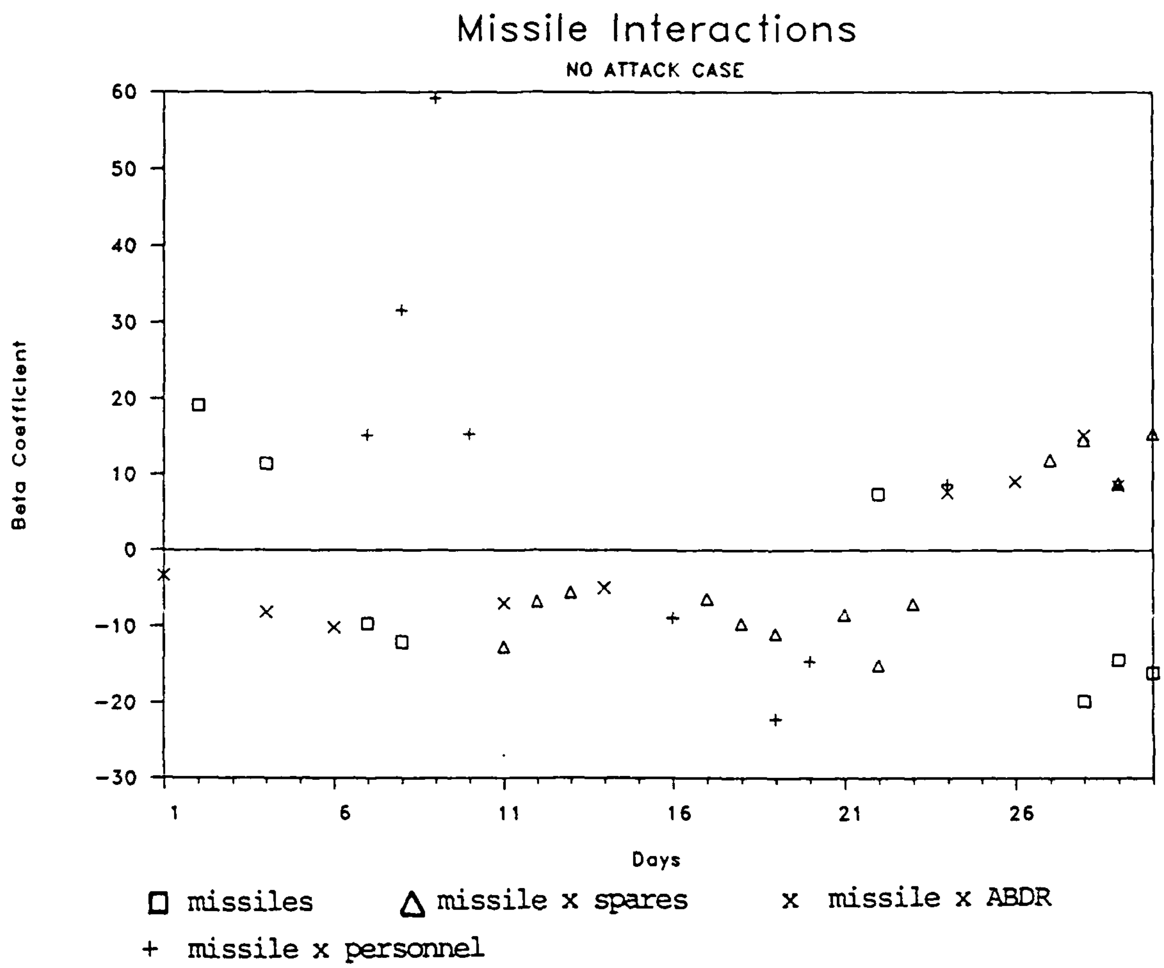


Figure 5.19

No-Attack Case -- Missile Interactions (1) available that ordinarily would not be repaired, while the high level of Missiles allows more of the flyable aircraft to be armed and fly into combat. However, the early flying, especially in the first few days where attrition rates are highest, may increase aircraft losses and thus decrease the number of sorties flown later. After Day 22, we see the expected effect where both resources allow more aircraft to be ready to fly and we have positive coefficients.

Missiles x Personnel interactions are discussed above. Figure 5.19 depicts the coefficients for this interaction term along with several of the other Missiles two-way interactions.

Missiles x Spares interactions are discussed above. Figure 5.19 shows this interaction term along with other important Missiles two-way interactions.

Missiles x Fuel interactions, shown in Figure 5.20, are mostly positive and found after Day 15 when both resources are at the high level. Both resources can be seen as essential consumable items necessary for the aircraft to fly. Having more available means more aircraft are available to fly.

Missiles x Fillers interactions are discussed above. Figure 5.20 depicts the coefficients for this interaction term along with several of the other Missiles two-way interactions.

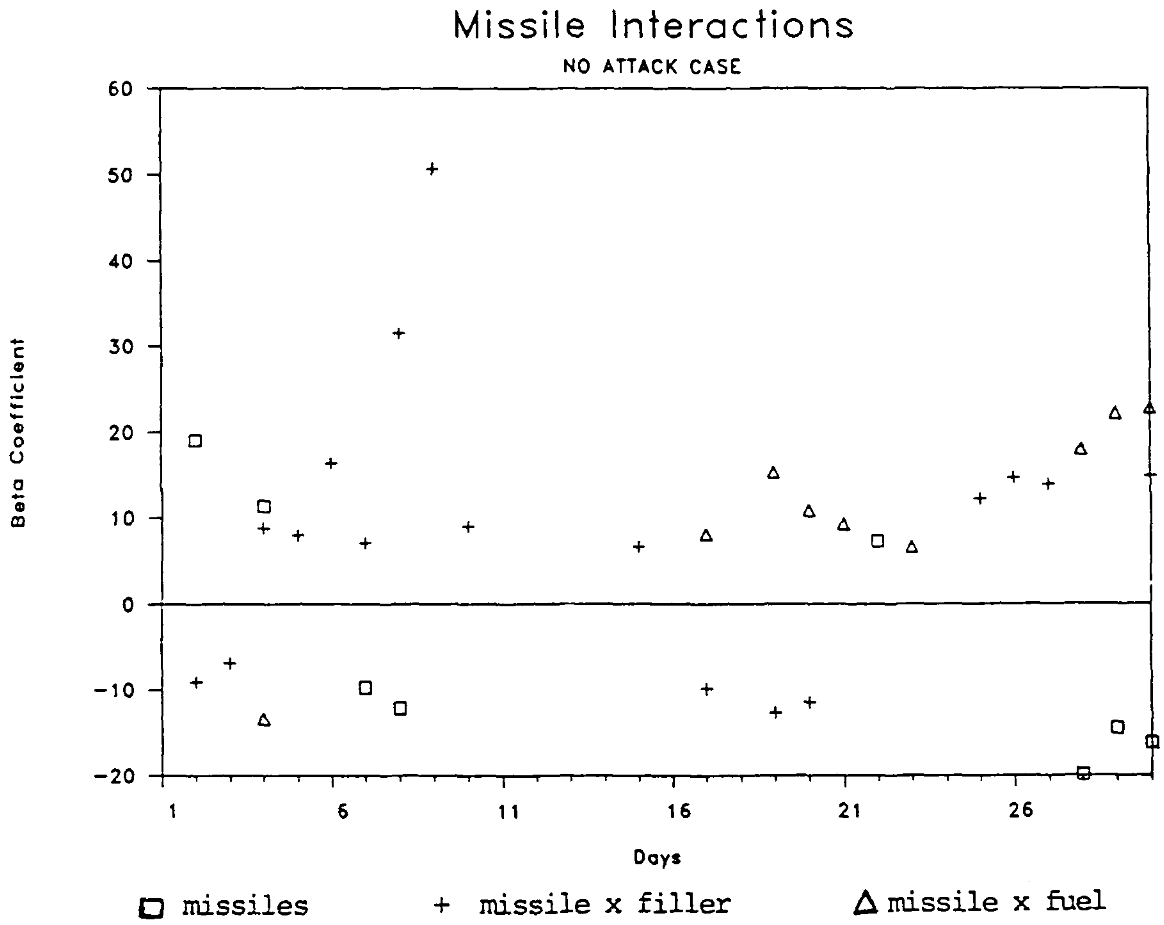


Figure 5.20

No-Attack Case -- Missile Interactions (2)

Net Effect and Summary. Missiles and its important two-way interactions with other main effects have a mixed overall impact. From Figures 5.19 and 5.20, it is obvious that some effects are negative while others are positive and we would expect some of these to cancel each other out. Figure 5.21 shows the net effect when we use the daily metamodels to predict the difference in sorties when Missiles is at the low level (all other factors high) in comparison to all factors at the high level. We see some early positive contributions, especially Day 9 at 110 sorties. In the middle time period, the coefficients are mostly negative and then shift to mostly positive later on. The overall impact seems to be positive with fairly minimal costs in terms of lost sorties later.

Main Effect: Fuel

Fuel by itself appears sporadically as a significant factor in the daily metamodels. Always negative when it is significant, Fuel appears in only six metamodels (see Figure 5.11). Since the high and low levels are the same until Day 15, we would expect no difference in effects until then. Thus the appearance of Fuel in metamodels before Day 15 is spurious. While the main effect is not very prevalent, several two-way interactions are important: Fuel x Fillers and Fuel x Missiles.

Fuel x Fillers interactions are discussed above. Figure 5.22 depicts the coefficients for this interaction term along

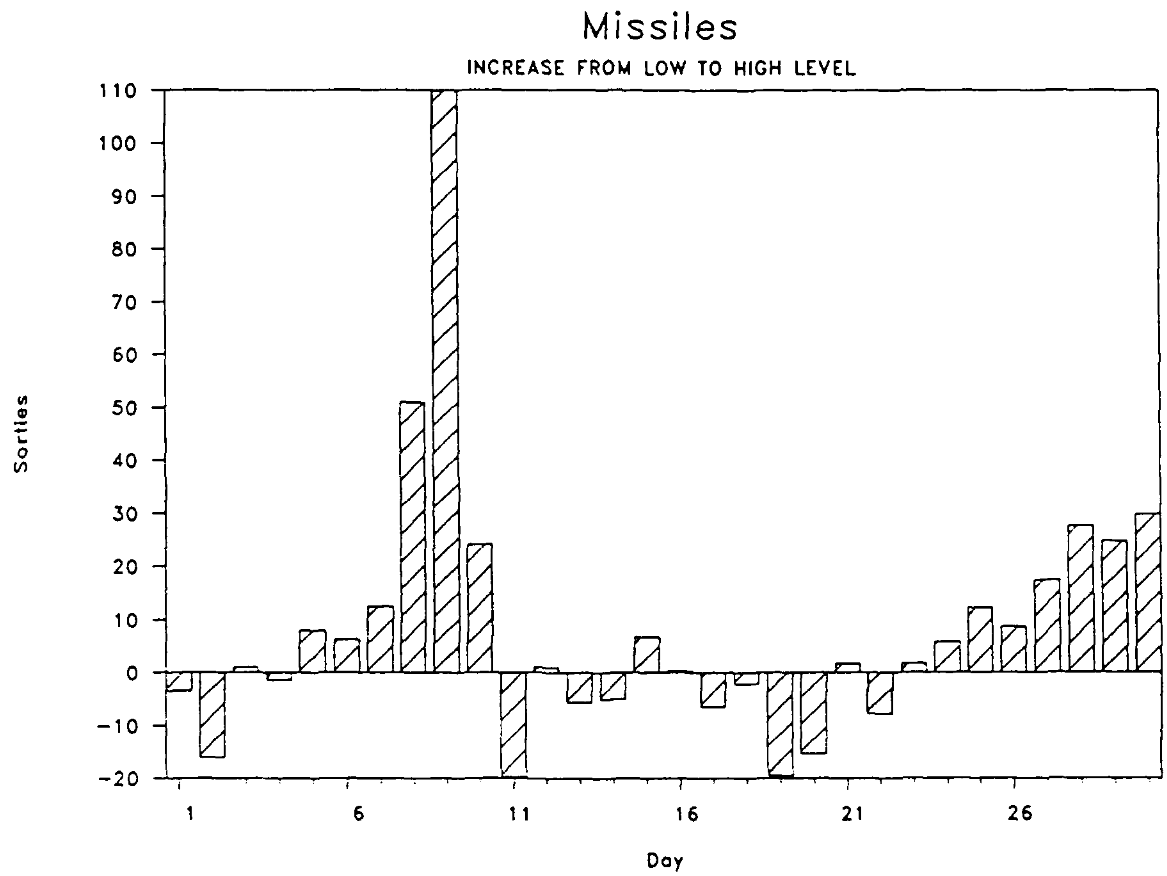


Figure 5.21

No-Attack Case -- Overall Contribution of Missiles

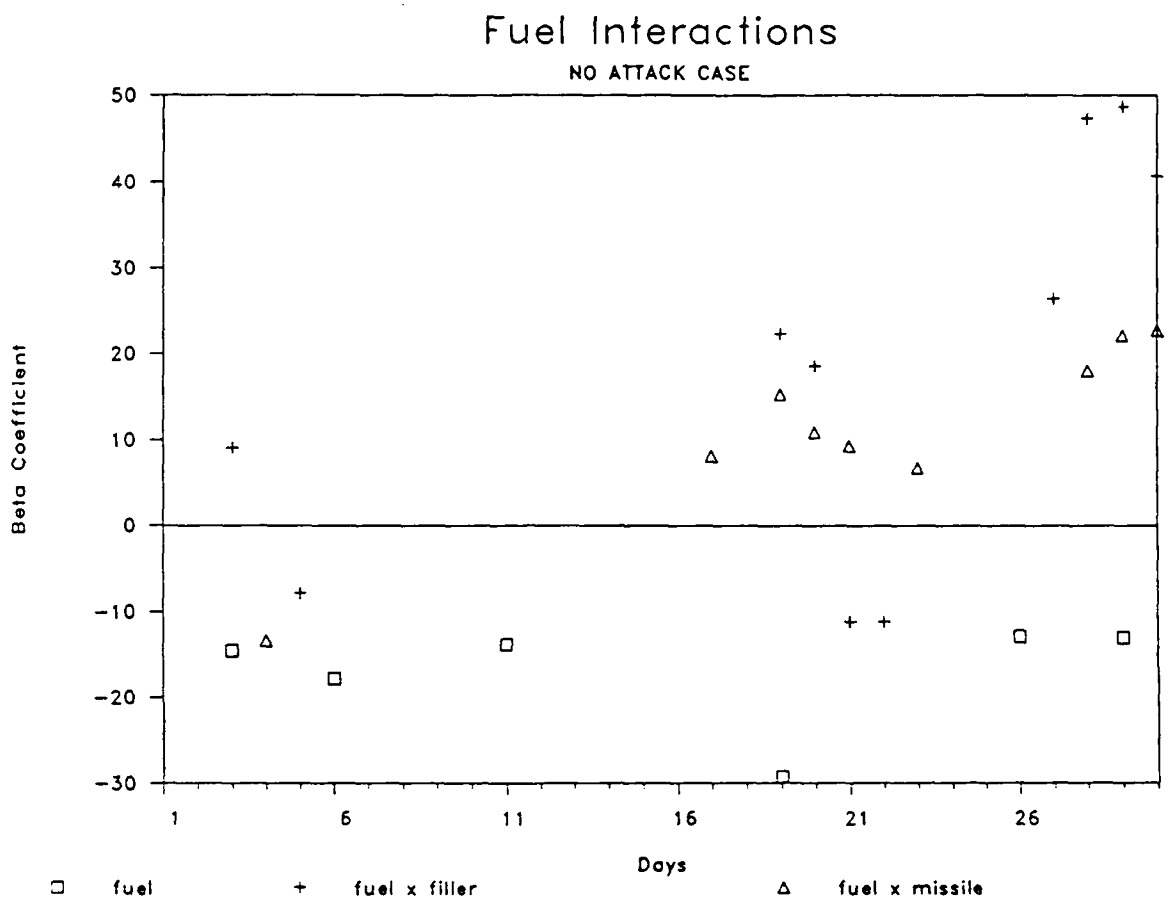


Figure 5.22

No-Attack Case -- Fuel Interactions

with that of the main effect and the Fuel x Missiles interaction.

Fuel x Missiles interactions are discussed above. Figure 5.22 depicts the coefficients for this interaction term along with that of the main effect and the Fuel x Fillers interaction.

Net Effect and Summary. Other two-way interactions with Fuel occur randomly as can be seen in Table 4.8. Examining the Fuel main effect without considering its two-way interactions with other main effects results in the erroneous conclusion that more fuel results in fewer sorties flown. We must look at the net effect of Fuel based on the metamodels containing all the significant effects. The net effect, shown in Figure 5.23, is small positive and negative contributions with no discernible pattern through Day 17. Then there is a five day period (Days 21 to 25) with negative coefficients bordered on each side by large positive contributions. Overall it appears that the effects of Fuel and its two-way interactions with other main effects essentially cancel out in the first seventeen days. After that the effect tends to be positive (except for the five day period from Day 21 to Day 25). Thus Fuel appears to be more important toward the end of the period.

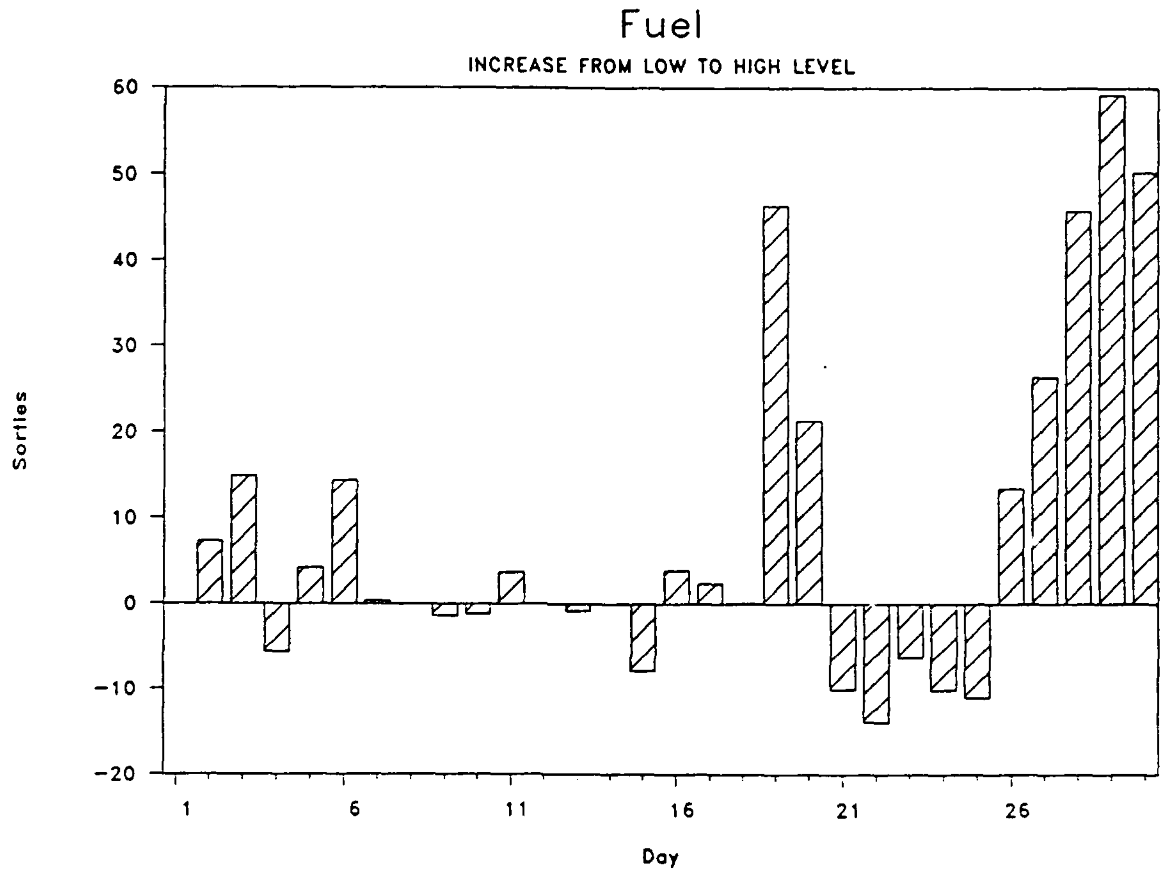


Figure 5.23

No-Attack Case -- Overall Contribution of Fuel

Main Effect: ABDR

ABDR by itself showed only sporadic, mostly negative coefficients when significant (see Figure 5.11). This seems to indicate that early repairs allow early flying and thus the loss of aircraft that otherwise would be available to fly later.

Significant interactions with ABDR, however, tend to be positive and appear primarily after Day 14 (see Figure 5.24). An exception is the interaction with Missiles which appears negatively four times in the first two weeks, but then shifts to positive results after Day 23.

Net Effect and Summary. The overall effect of ABDR and its interactions are shown in Figure 5.25. The coefficients oscillate between positive and negative and are relatively small in magnitude (i.e. less than 15 sorties per day). ABDR has positive benefits when other resources are also available. Due to long repair times, these benefits generally show up in later periods.

Other Main Effects: AIS, Attrition, Support Equipment, and Recovery

The remaining main effects appear only occasionally. Below are the net effects of each as predicted from the daily metamodels by calculating the difference in sorties when all factors are at the high level and when all are high except the factor of interest.

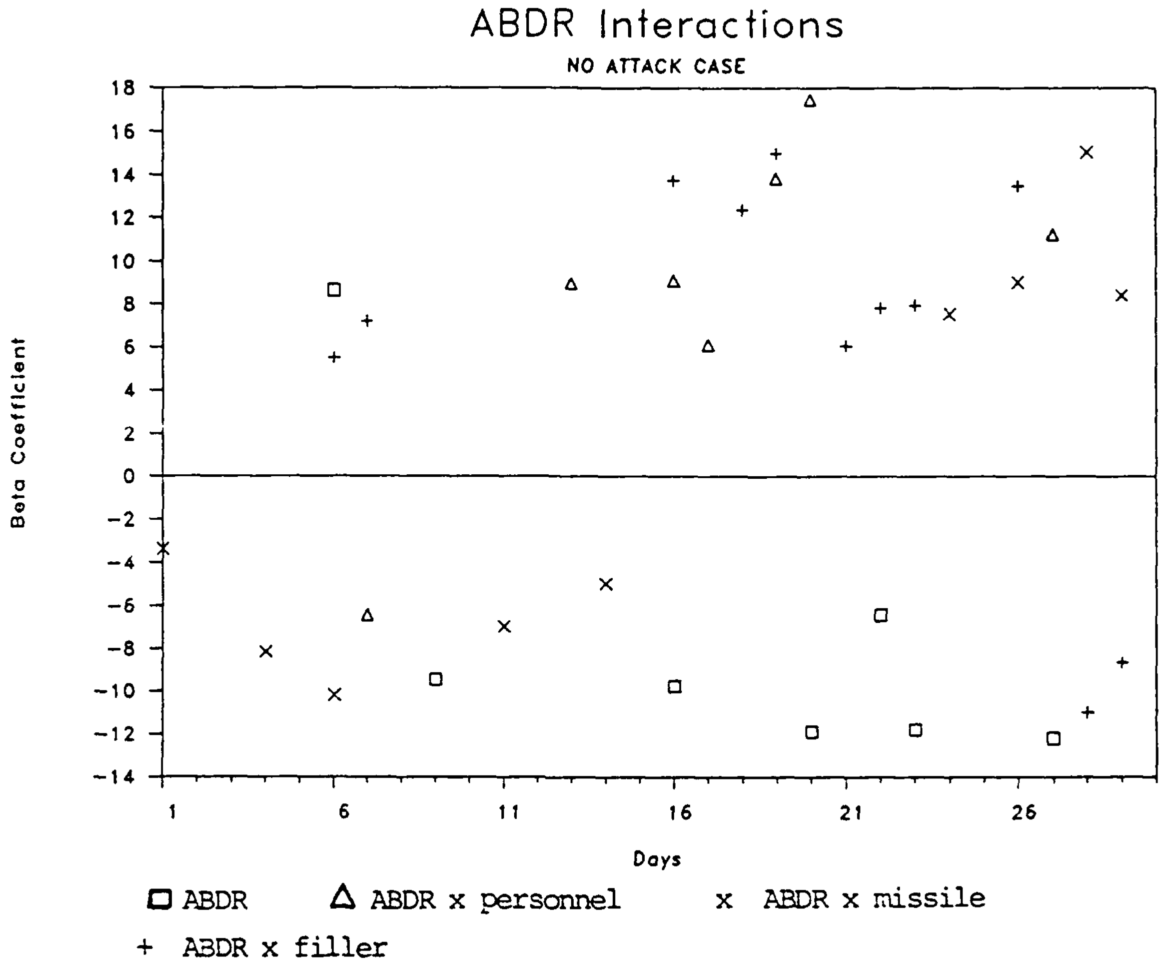


Figure 5.24

No-Attack Case -- ABDR Interactions

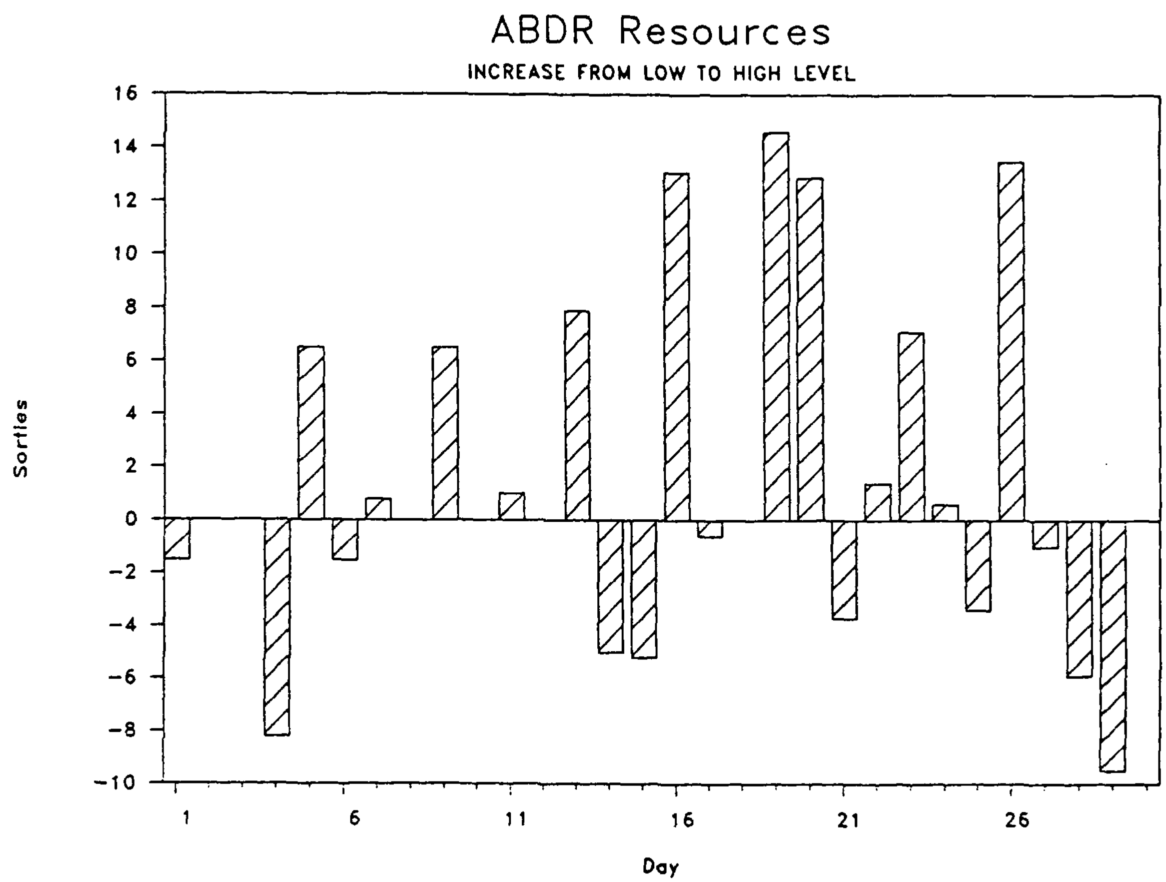


Figure 5.25

No-Attack Case -- Overall Contribution of ABDR

Net Effect of AIS. Figure 5.26 depicts the contributions of AIS at the high level as opposed to the low level. We see that the early contributions are nearly all positive, while later contributions are negative. Relative to other factors discussed above, the magnitude of the daily sorties is small across all days, ranging from +12 to -12.

Net Effect of Attrition. Figure 5.27 depicts the contributions of Attrition over time. For the most part, the high (i.e. most favorable) level of attrition has a positive effect compared to the low level. Magnitudes of additional sorties per day are small, under ten sorties per day except for two days with around 15 sorties.

Net Effect of Support Equipment. The additional sorties realized from having Support Equipment at the high level are shown in Figure 5.28. Most are positive and in the middle time periods. There is a definite negative effect in the last four days as well as in the first two days. Again the relative magnitude of the difference in sorties is small.

Net Effect of Recovery. The contributions of Recovery resources are depicted in Figure 5.29. Both positive and negative effects are seen across the entire period. This is difficult to explain since Recovery resources are relevant only when the base is attacked; thus the results for this factor are spurious.

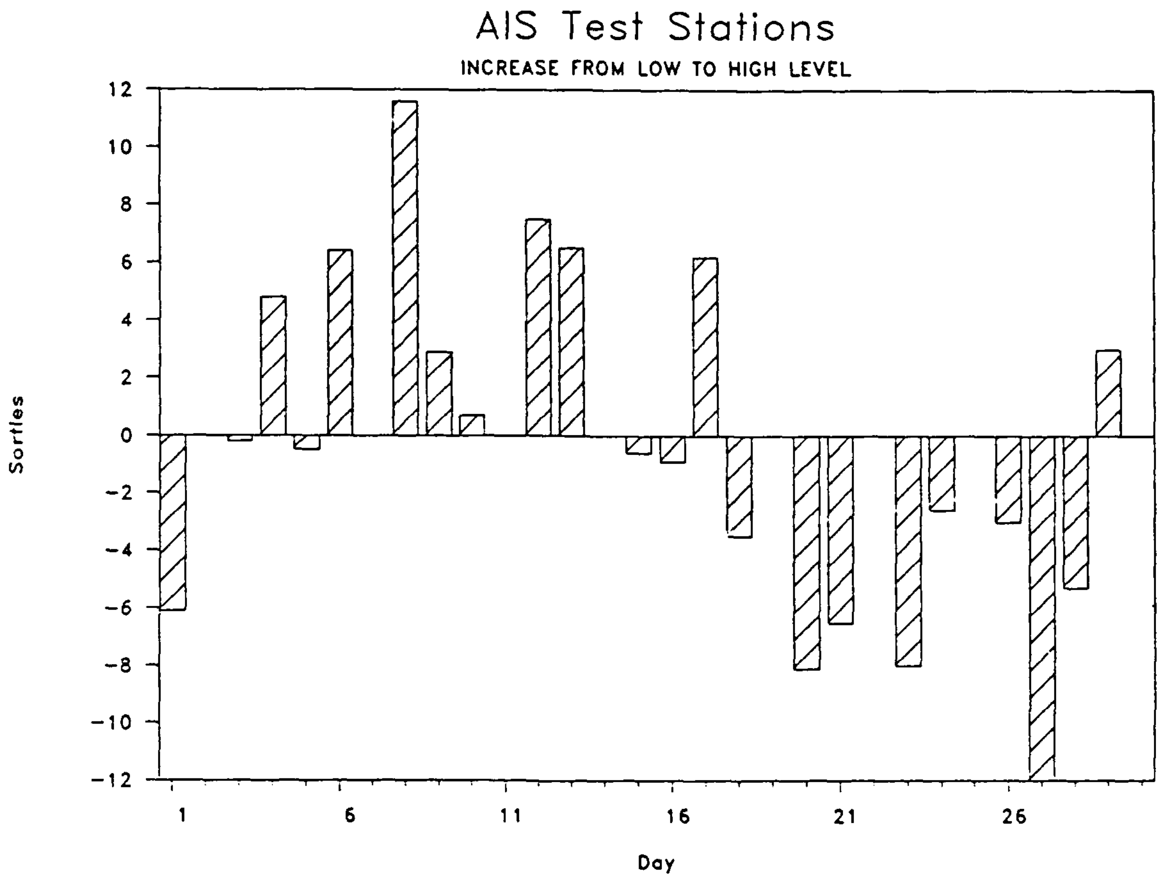


Figure 5.26

No-Attack Case -- Overall Contribution of AIS

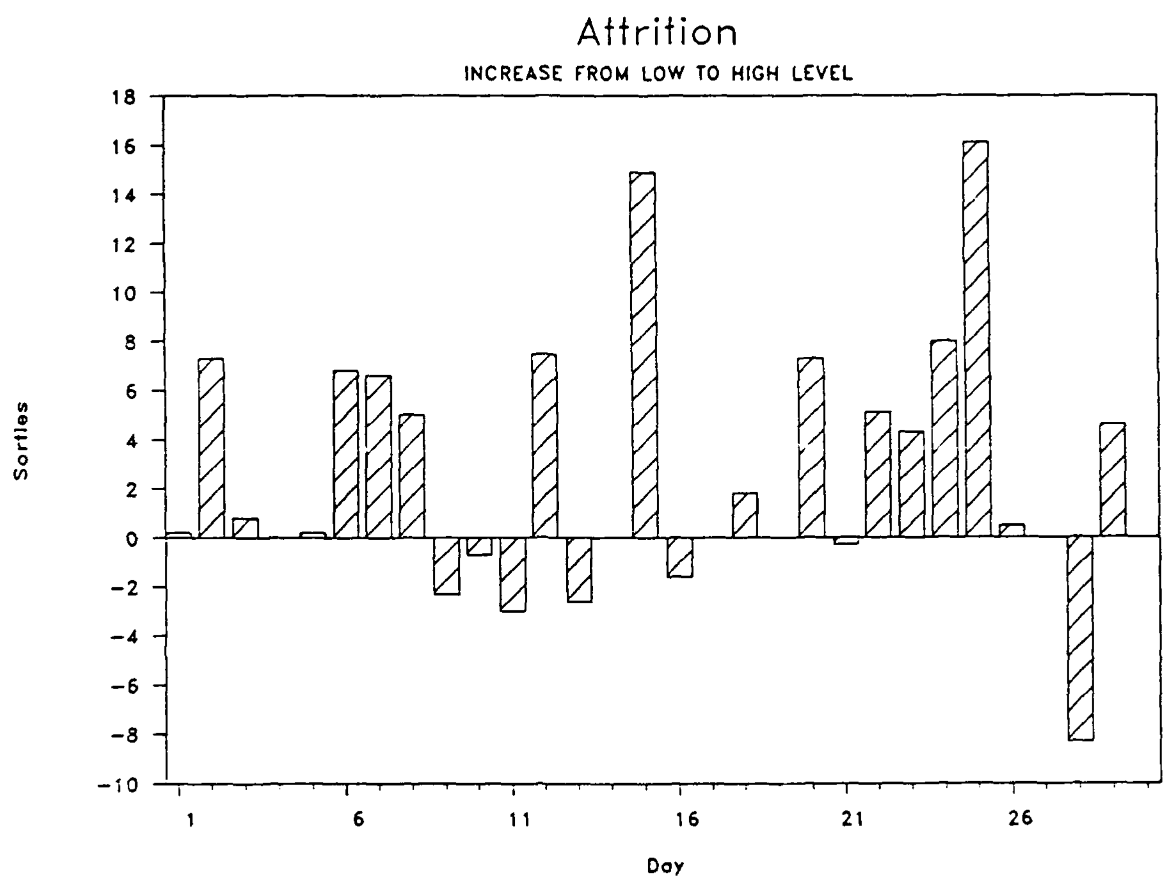


Figure 5.27

No-Attack Case -- Overall Contribution of Attrition

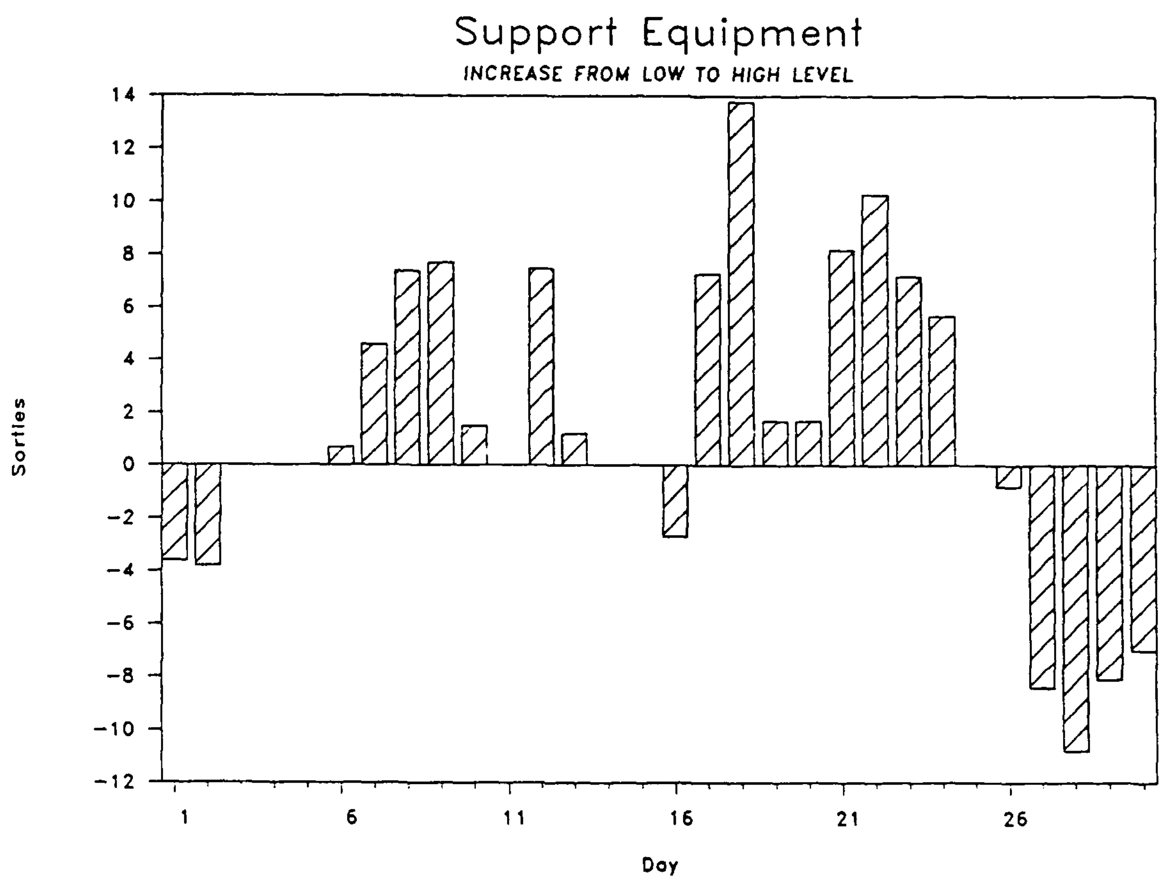


Figure 5.28

No-Attack Case -- Overall Contribution of Support Equipment

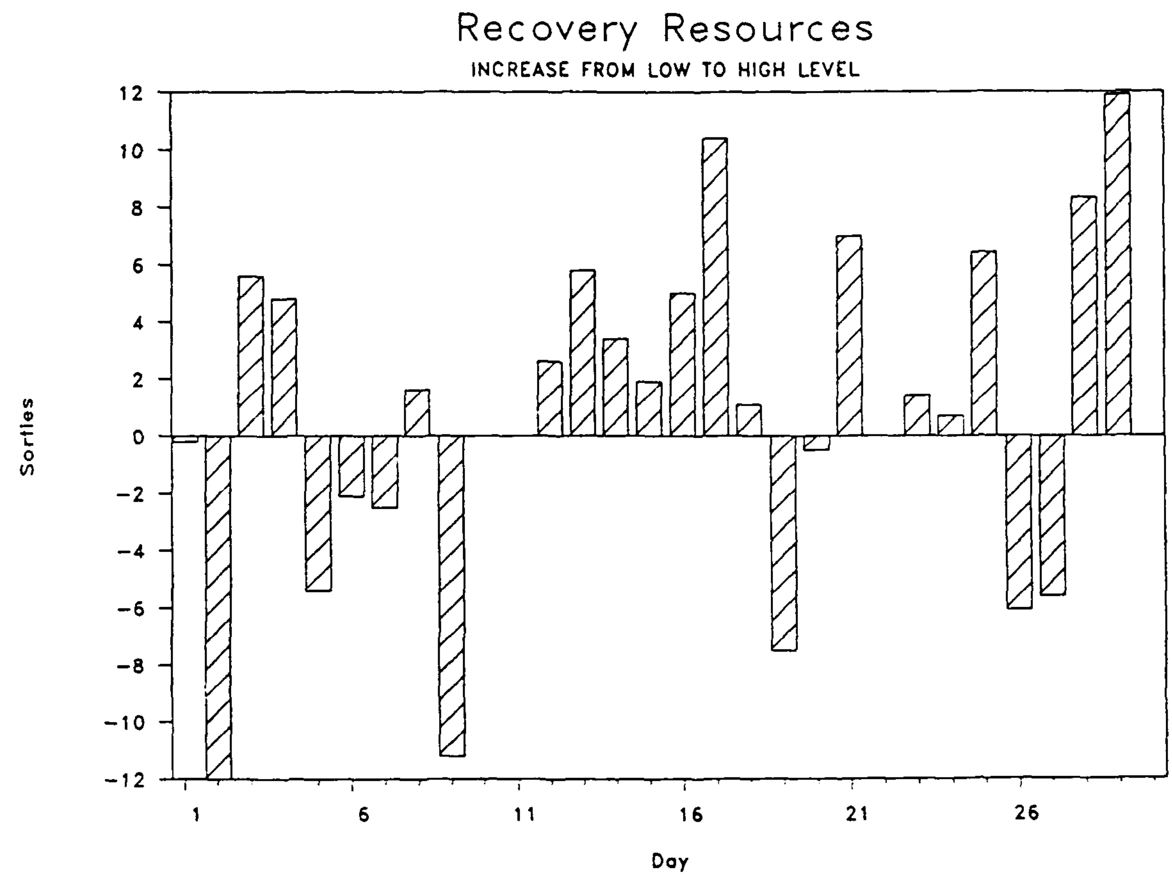


Figure 5.29

No-Attack Case -- Overall Contribution of Recovery Resources

Attack Case Factor Results

Overall results for the attack case metamodels are shown in Table 4.11. Entries in the table are the beta coefficients of the factors that are significant in each daily metamodel estimated by stepwise regression. The beta coefficient represents the change in the number of sorties flown when a factor is at the high level as opposed to the low level.

In comparison to the no-attack case, the attack case results are a much "cleaner" visually in the table, i.e. factors tend to show definite trends over time and with little changing of the signs of the coefficients. All main factors show a significant trend or pattern with the exception of AIS and Spare Parts. Although AIS is never significant by itself, it is nonetheless important because of interactions with several other main factors. Spare Parts shows two days with negative coefficients (Days 2 and 3) and then several intermittent days with positive contributions. It also has two-way interactions with other main effects that are important.

Figures 5.30 and 5.31 show the beta coefficients of the most significant main factors over time. These factors are ABDR, Recovery, Personnel, Support Equipment, Attrition, Fillers, Missiles, and Fuel. With only minor exceptions, all of these main effects contribute positively to the sortie generation effort. Referring to Figure 2.2, we see that is

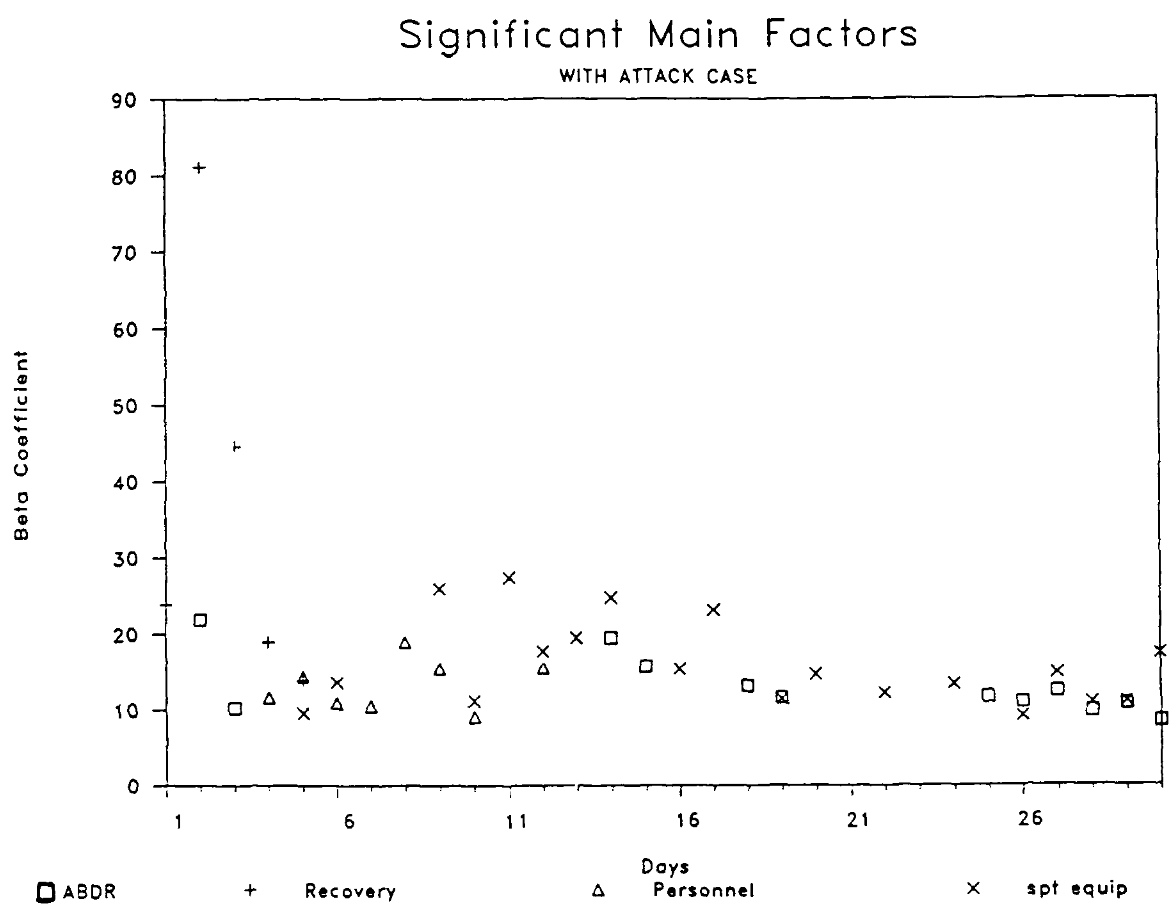


Figure 5.30

Attack Case -- Significant Main Factors (1)

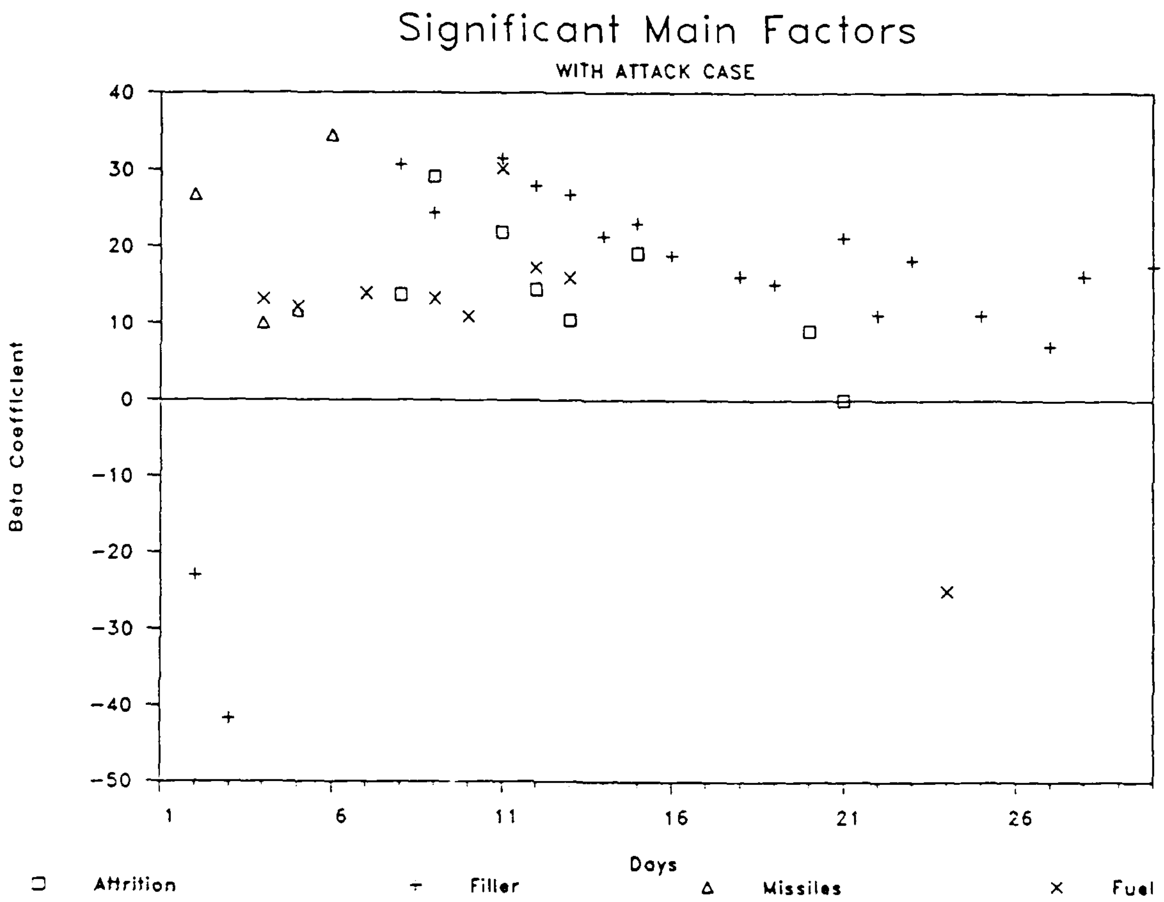


Figure 5.31

Attack Case -- Significant Main Factors (2) exactly the result we would expect. Some factors contribute throughout the 30-day time period, while others are either early or late contributors. The early to mid-period contributors appear to be Recovery, Personnel, Missiles, and Fuel. Attrition is a mid-period contributor, while mid to late contributors appear to be Fillers, ABDR, and Support Equipment. Below we will examine each of the main effects and their most important two-way interactions.

Main Effect: Recovery Resources

Recovery resources consist of the equipment and personnel necessary to repair runways, taxiways, and facilities damaged during attacks on the air base. Figure 5.30 depicts the significant coefficients for Recovery along with some of the other main effects. With this factor at a high level, additional sorties can be flown, but only in the first five days which is when the attacks occur. This indicates that runways and taxiways are cleared of rubble and holes in the pavement are repaired so that flying can resume sooner than at the low level of Recovery. The magnitude of the coefficients is large -- over 81 sorties on Day 2. Recovery has few interactions with other main effects; most of the net contribution for this factor comes from the main effect itself as can be seen in Figure 5.32. Thus the effect of Recovery is very significant, but limited to a very short period of time. However, the value of these sorties flown

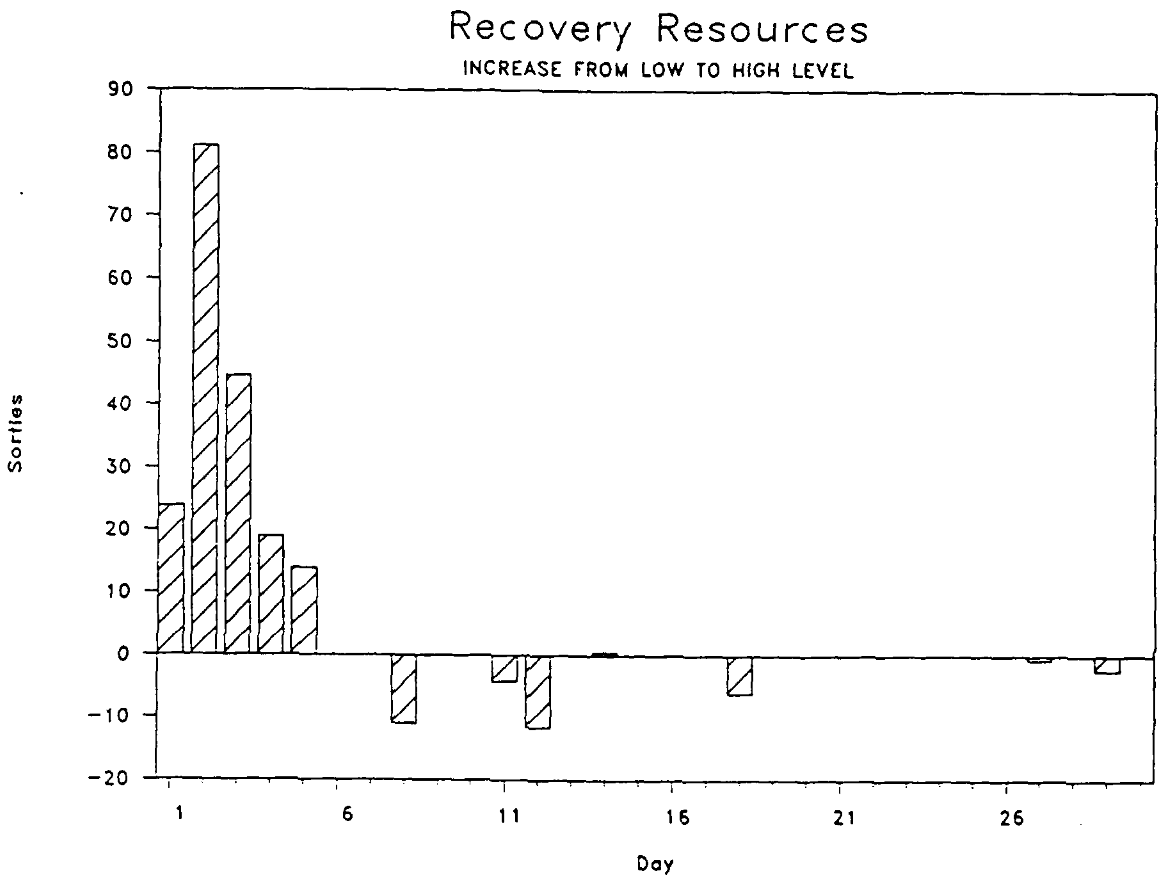


Figure 5.32

Attack Case -- Overall Contribution of Recovery Resources may be very important and influence the outcome of the war; thus the importance of this factor should not be discounted.

Main Effect: Personnel

The Personnel factor seems to begin its contribution where Recovery stops. Days 4 to 12 are where the high level of people has a positive impact on the level of sorties flown (see Figure 5.30). More people available generally allows more aircraft to be repaired or serviced at any point in time. Thus aircraft should be returned to flying sooner. Expected additional sorties per day due to Personnel range from 9 to 19 during this period. Personnel also has several important two-way interactions with other main effects: Support Equipment, ABDR, and Missiles.

Important Interactions. Figure 5.33 shows the coefficients of the daily metamodels where Personnel and its interaction terms are significant. Two negative interactions with personnel are Support Equipment and ABDR. Both of these interactions tend to return aircraft to operational flying status sooner than if the resources were at low levels. As a result, more aircraft are flown earlier, with more early losses, which results in fewer aircraft to fly later. Again, there is an apparent trade-off between early sorties and later sorties. In contrast, the Personnel x Missile interaction is positive and appears in daily models after Day 12, ranging from 13 to 20 sorties per day. Missiles are

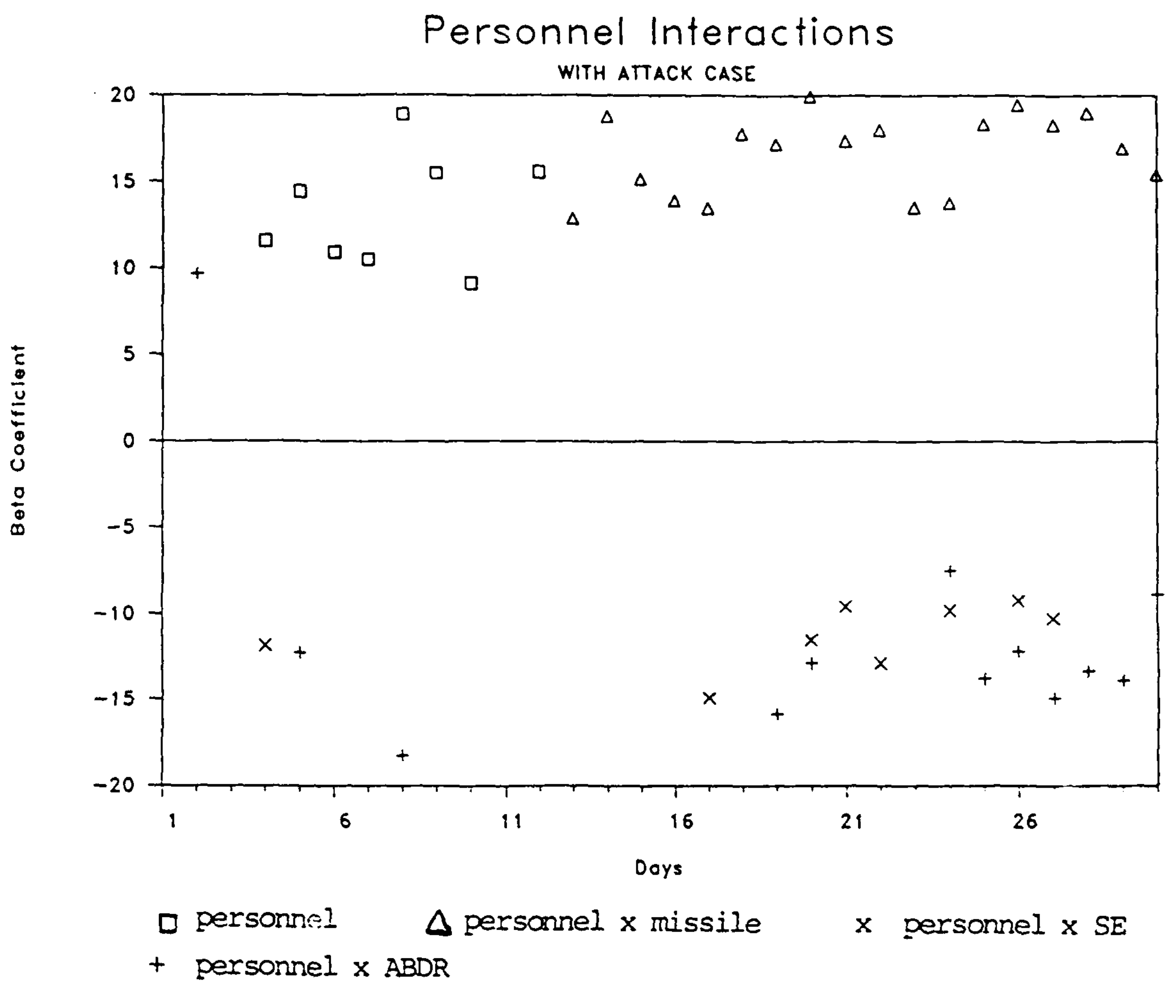


Figure 5.33

Attack Case -- Personnel Interactions

delivered as components which must be assembled manually. If we have both high levels of missiles (i.e. lots of unassembled components) and the people to assemble them, we will potentially have more combat-armed aircraft to fly.

Net Effect and Summary. Figure 5.34 depicts the net effect of increasing Personnel from the low level to the high level. Overall, the impact of Personnel is positive, particularly in the first 16 days, although we do see some relatively small negative results after that. When significant, the high level of Personnel contributes about 11 extra sorties per day when positive and "costs" about 3 sorties per day when negative.

Main Effect: Fuel

Fuel, as shown in Figure 5.31, is an early positive contributor to the flying effort. However, these results for the main effect seem spurious since there is no difference between the high and low levels until Day 15. For some reason, all of the positive contributions associated with Fuel in the daily metamodels come before Day 14. However, Fuel also has important interactions with many of the other main effects.

Important Interactions. Figures 5.35 and 5.36 show the many opposing interactions involving Fuel. From these figures, we see that positive coefficients result from Fuel's two-way interactions with Support Equipment, Fillers, and

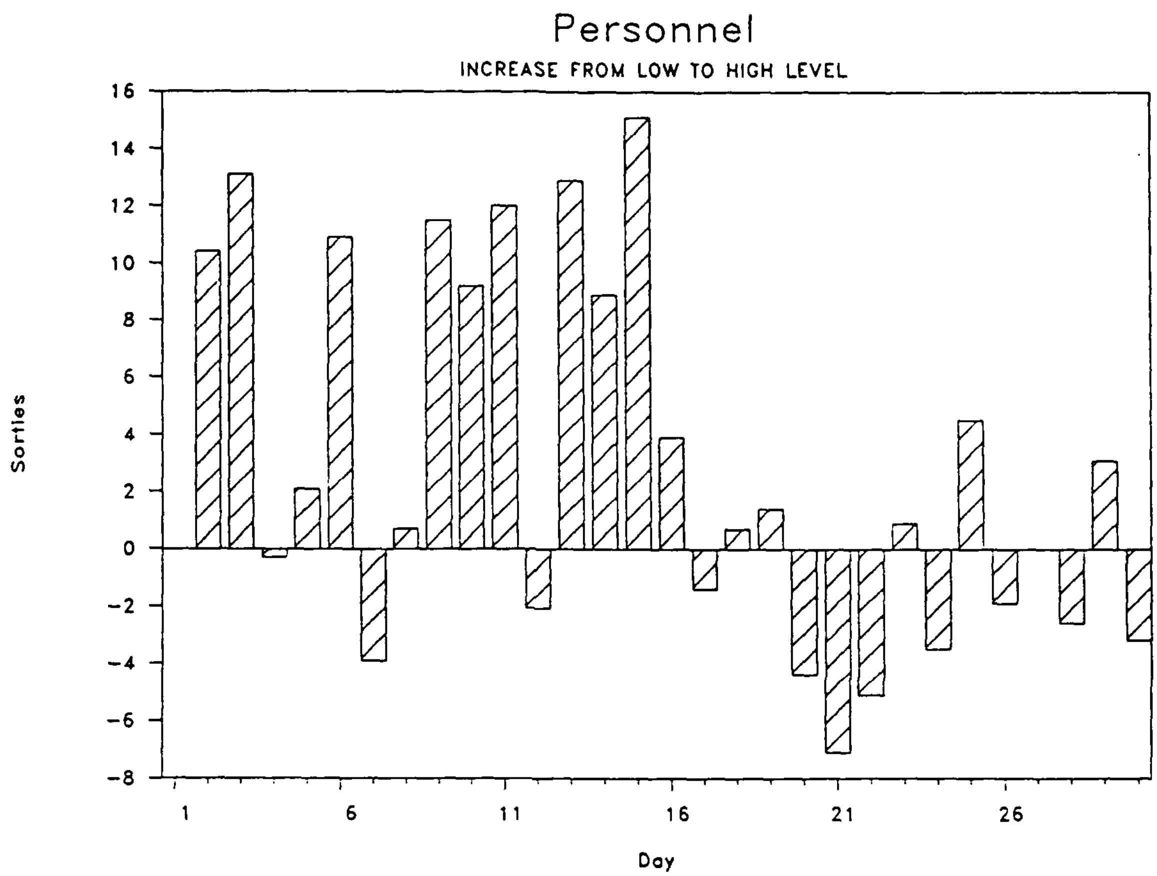
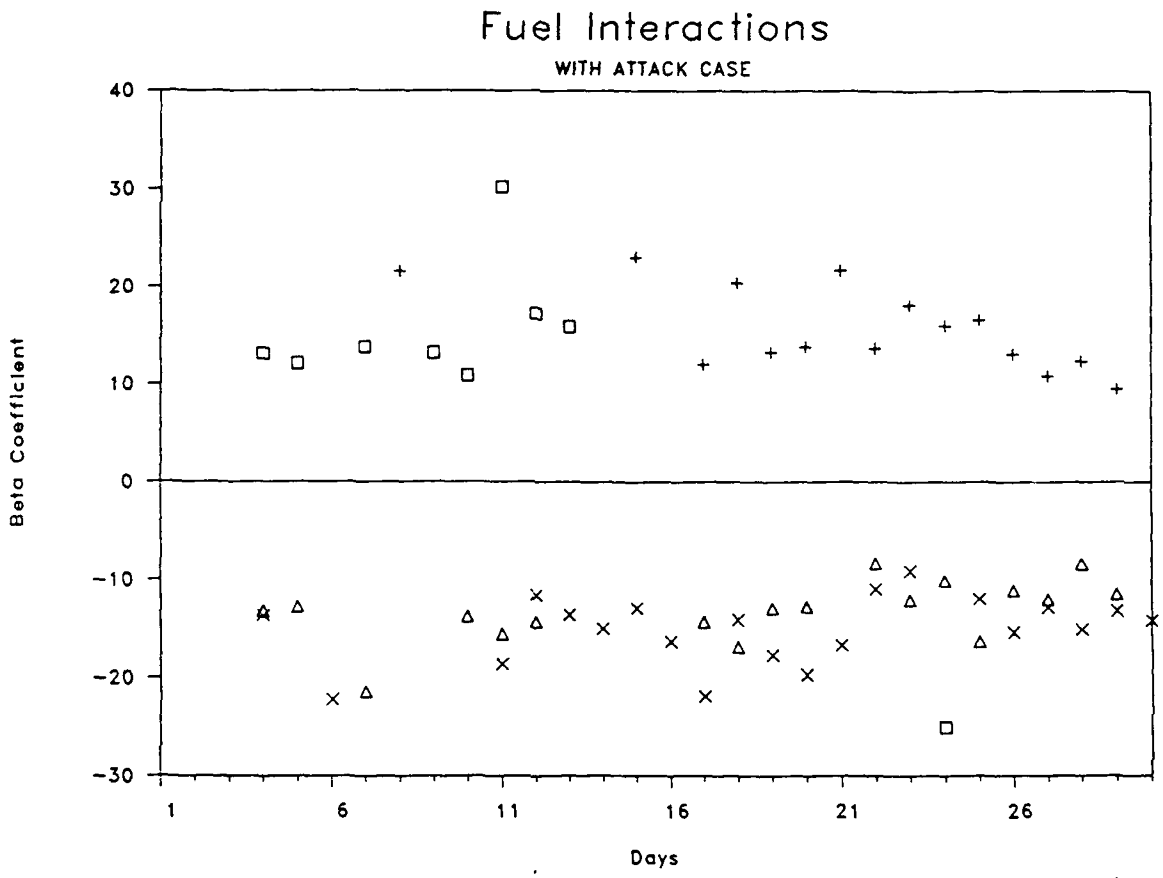


Figure 5.34

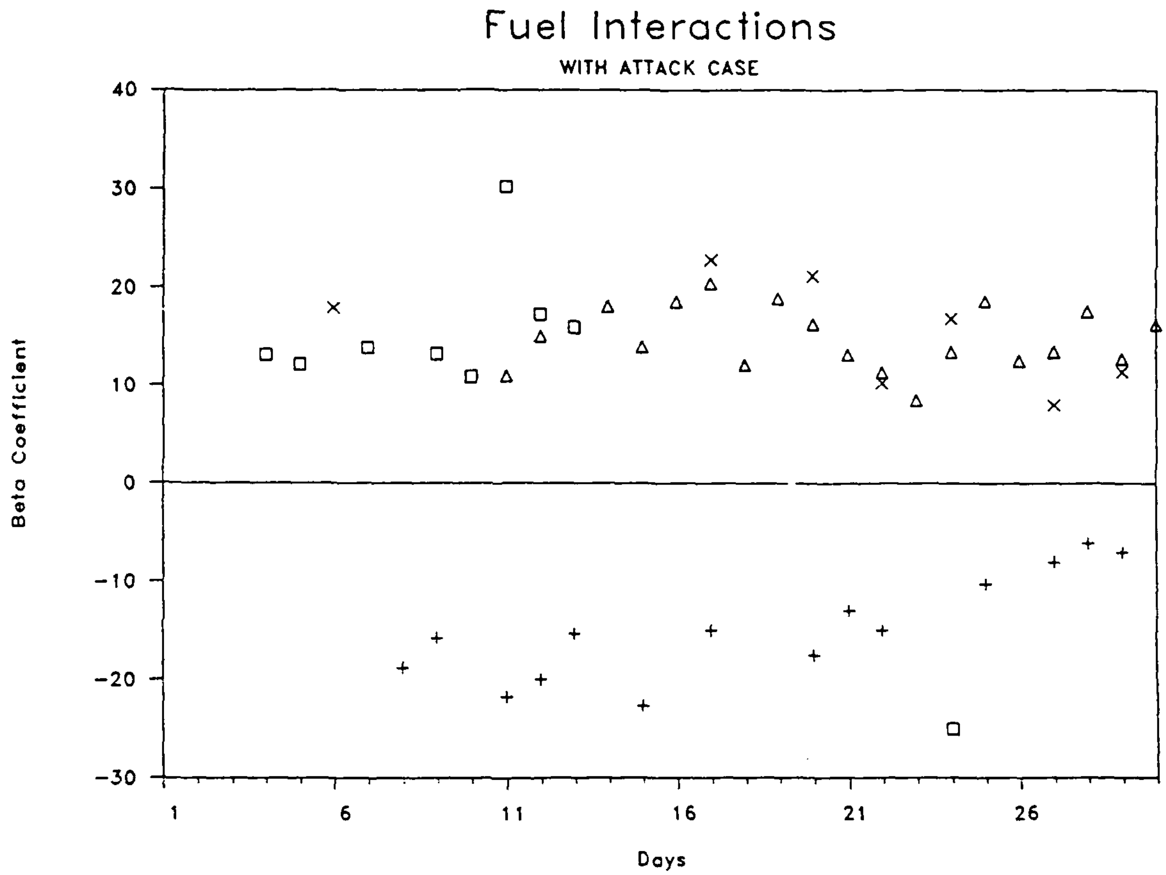
Attack Case -- Overall Contribution of Personnel



□ fuel + fuel x SE △ fuel x spares
x fuel x missile

Figure 5.35

Attack Case -- Fuel Interactions (1)



□ fuel △ fuel x AIS x fuel x fillers
+ fuel x attrition

Figure 5.36

Attack Case -- Fuel Interactions (2)

AIS. These interactions are predominant in the last fifteen days. Generally, the high levels result in aircraft either being repaired or serviced that otherwise would not fly and thus more sorties are flown. In contrast, Fuel x Attrition, Fuel x Spares, and Fuel x Missiles have negative coefficients. In general, they allow more flying early and thus a cost is paid in terms of less flying later because of aircraft losses.

Net Effect and Summary. Figure 5.37 shows the net effect of the Fuel resource and its interactions. Negative contributions dominate the first 13 days; then the net contributions turn mostly positive (but very small except for Day 24). Overall these results for Fuel highlight the complex interdependencies found in the sortie generation process. The answers or reasons are not always clear or intuitive.

Main Effect: ABDR

The significant coefficients of ABDR are shown in Figure 5.30 along with those of other main effects. More ABDR capability generally means that more battle damaged aircraft return to flying status and hence more sorties are flown. Such positive contributions are seen on Days 2 and 3, and then intermittently in daily models after Day 13. The positive contributions of ABDR as a main effect are modified by its two-way interactions with Missiles and Personnel.

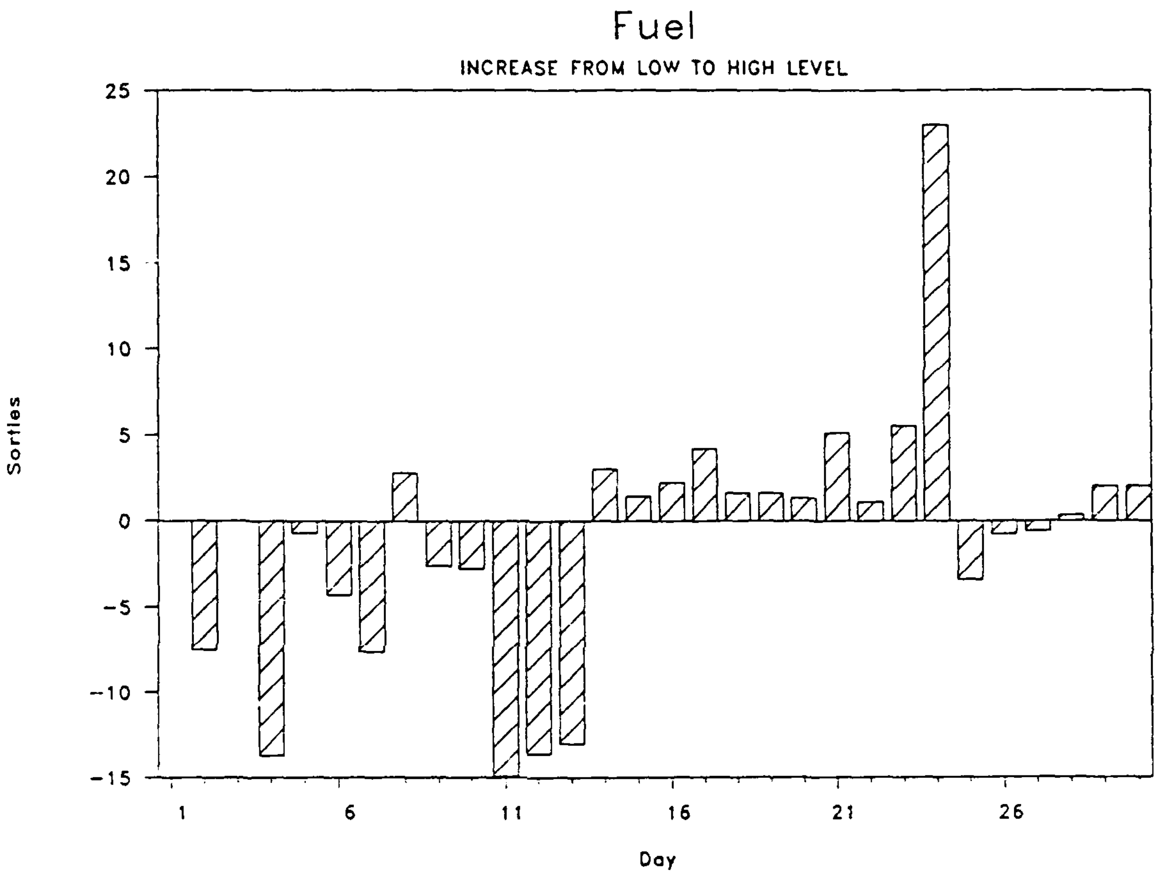


Figure 5.37

Attack Case -- Overall Contribution of Fuel

Important Interactions. The ABDR interactions have mixed effects and are shown in Figure 5.38. The ABDR x Missiles interaction is generally positive (appearing in the models of weeks 2 and 3). The exception is some very large negative coefficients in the models for Day 2 and Day 3. The size of these negative coefficients (-47 and -17) plus the slow nature of the ABDR process make it unlikely that early flying (i.e. early losses) resulted in lost sorties on Days 2 and 3. We suspect some other interaction with attacks in these early days that is not obvious. The positive coefficients in weeks 2 and 3 are due to more aircraft available from battle-damage repair that also have missiles available and thus more sorties are flown. In contrast, the ABDR x Personnel interaction is mostly negative and appears predominantly in the last week or so. This is due to more people available to fix damaged aircraft and hence many more are returned to flying sooner. Subsequently more are lost to attrition and unavailable for flying in the later days.

Net Effect and Summary. The expected net effect of ABDR and its interactions is shown in Figure 5.39. Here we see a negative effect in the early days, mostly positive contributions in the middle, followed by small negative contributions during the last six days. Overall there are some complex interdependencies which are unclear, especially in the first week.

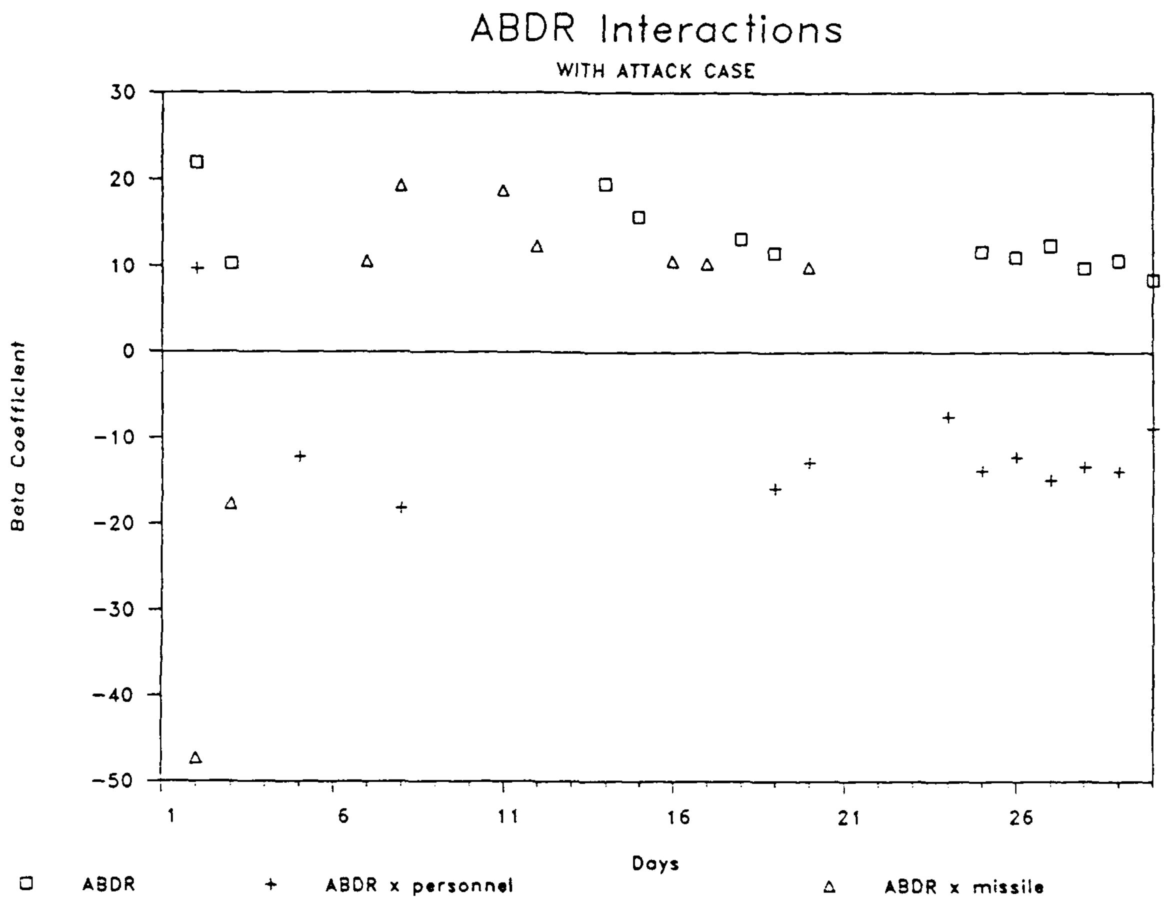


Figure 5.38

Attack Case -- ABDR Interactions

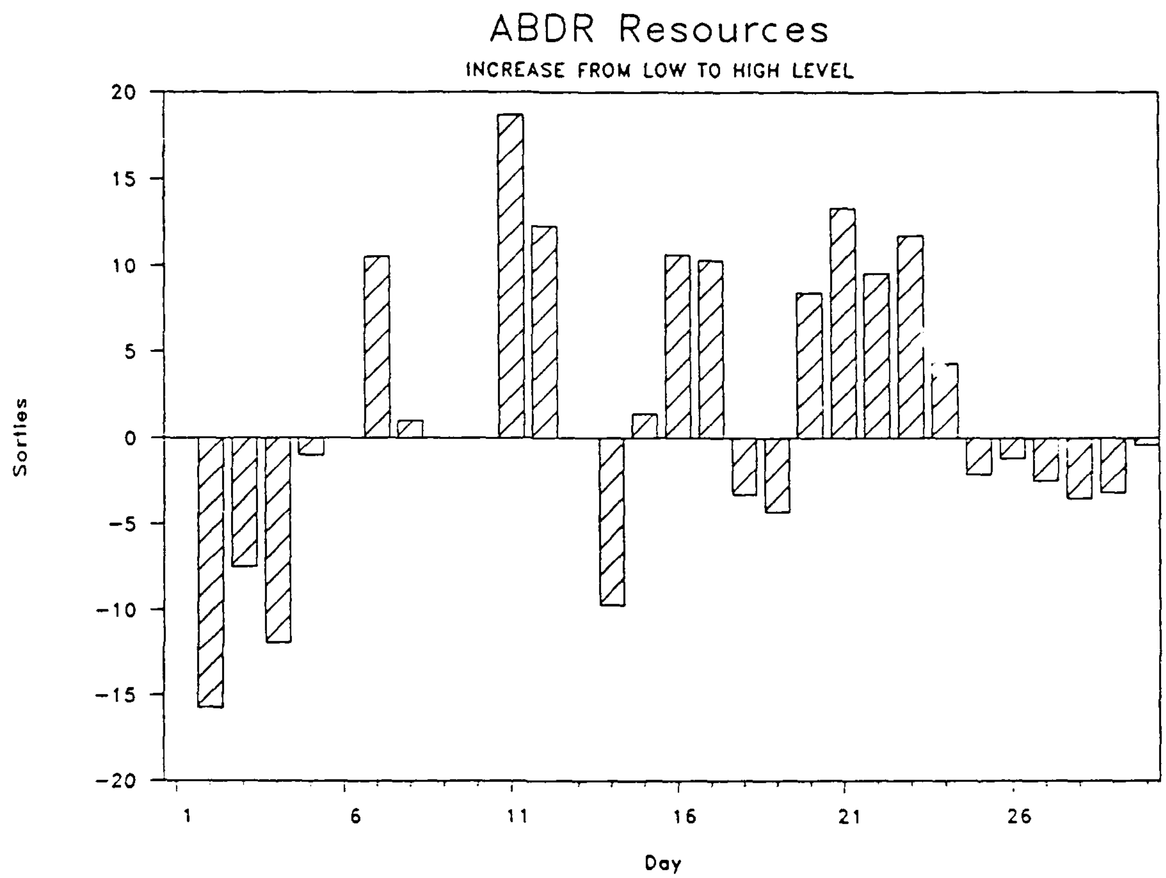


Figure 5.39

Attack Case -- Overall Contribution of ABDR

Main Effect: Attrition

Attrition appears as a significant factor primarily in the second week. It is plotted in Figure 5.31 along with some of the other significant main effects. By the second week, enough sorties have been flown so that the attrition rates become more favorable. The delay in the appearance of the Attrition factor is most likely caused by the attacks on the air base which prevent or slow down flying. The delay is evident in Figure 5.40 where the Attrition effect and its interaction with Fuel are shown.

Important Interactions. While the high level (i.e. more favorable) attrition level resulted in positive coefficients over time, the Attrition x Fuel interaction is negative, mostly ranging from -13 to -22 in the second and third weeks. Having fuel available allowed more sorties to be flown and thus more aircraft to be lost (even though the rate was lower) early on so that fewer sorties per day were eventually flown.

Net Effect and Summary. Figure 5.41 shows the expected net effect of having Attrition at the high or more favorable level. The result is not what we would expect. As is evident, the effects are almost all negative. This is a good example of the complexity and interdependencies within the logistics infrastructure and the air base system, particularly in a hostile environment.

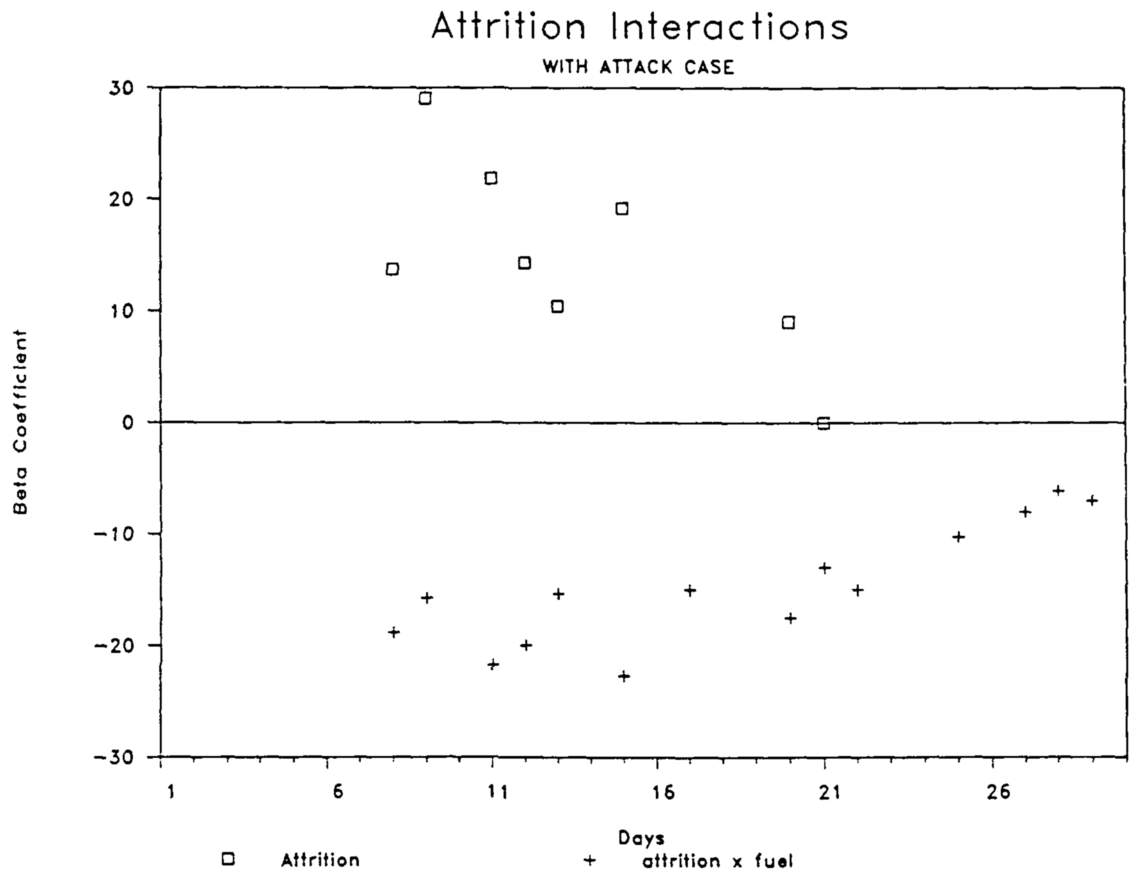


Figure 5.40

Attack Case -- Attrition Interactions

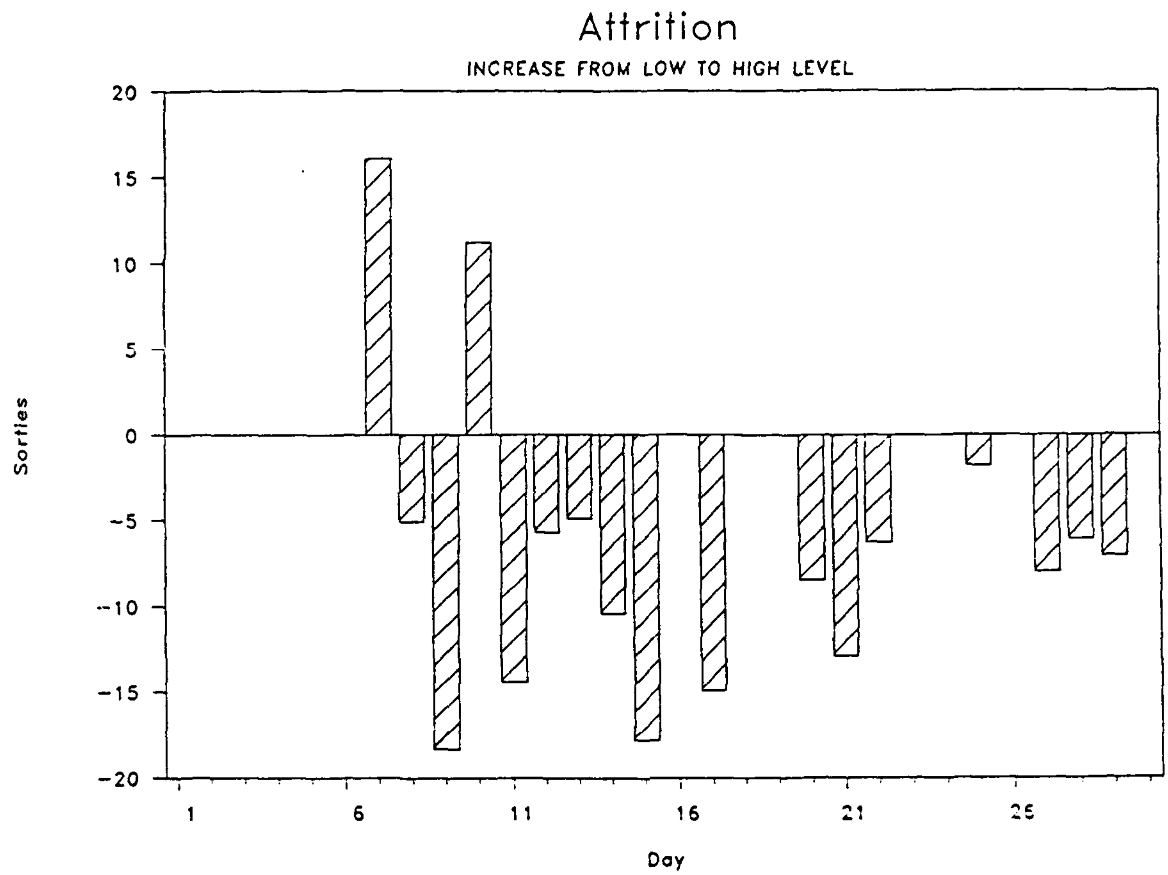


Figure 5.41

Attack Case -- Overall Contribution of Attrition

Main Effect: Filler or Replacement Aircraft

Fillers are shown in Figure 5.31 along with other significant main effects. Fillers have negative coefficients in the models for Day 2 and 3, but are positive after Day 7. The Day 2 and 3 results may be that the fillers allowed more sorties to be flown in the first few days when attrition rates were high, and thus resulted in fewer aircraft to fly. However, the size of the coefficients (-23 and -42 sorties) makes this unlikely. Here again it seems there is an interaction of some sort, possibly caused by the attacks, which is not readily apparent. Whatever the reason, the impact is short-lived and shifts to positive coefficients which one would expect: more aircraft should equal more sorties. Two interaction terms help to increase the positive contribution of Fillers.

Important Interactions. Fillers interacts positively with both Spares and Fuel as shown in Figure 5.42. The Filler x Spares interaction appears first in Days 2-6 with coefficients ranging from 18 to 60 sorties per day, and then again after Day 11 with coefficients ranging from 11 to 28 sorties per day. The Filler x Fuel interaction is intermittently positive, ranging from 8 to 22 sorties per day. It appears in 7 daily models, mostly after Day 15.

Net Effect and Summary. Figure 5.43 shows the net effect of having Fillers at the high level rather than the low. As is evident, Fillers make significant positive

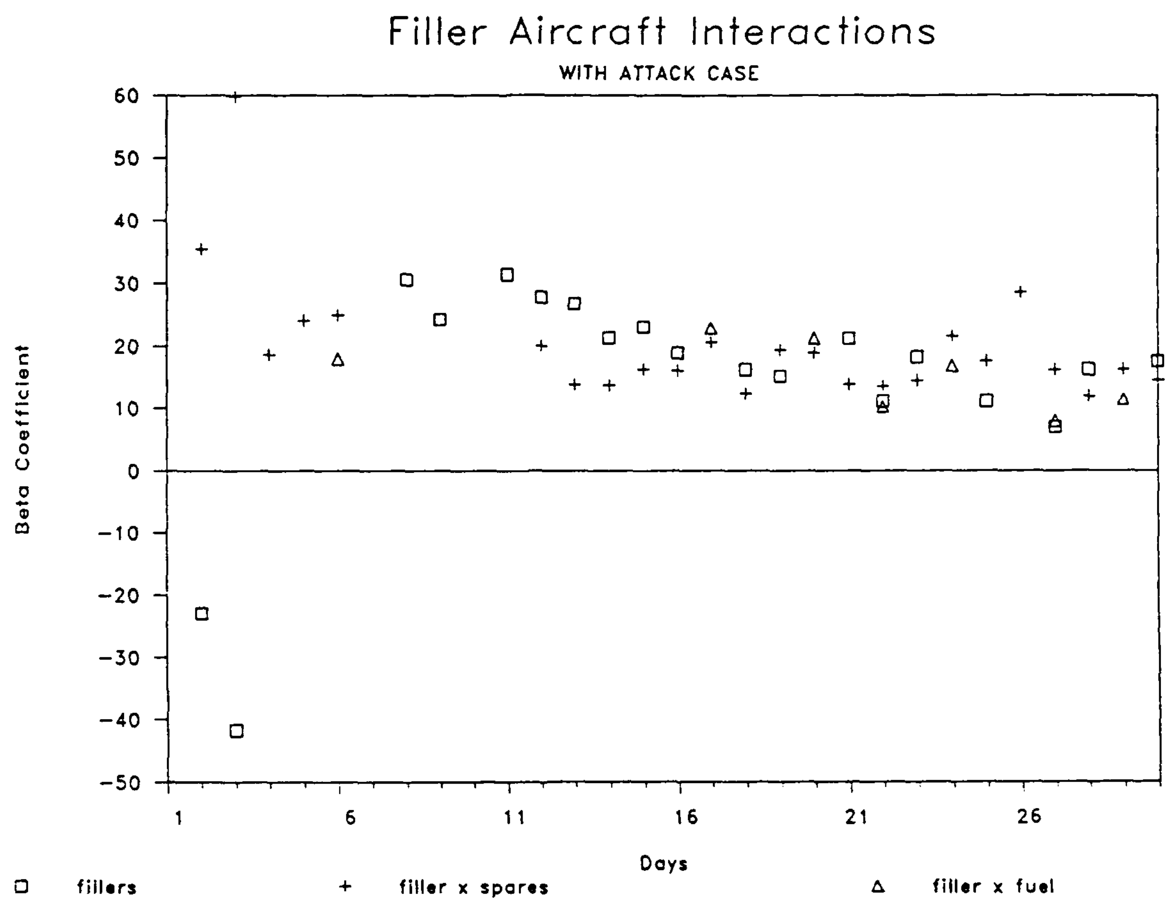


Figure 5.42

Attack Case -- Filler Aircraft Interactions

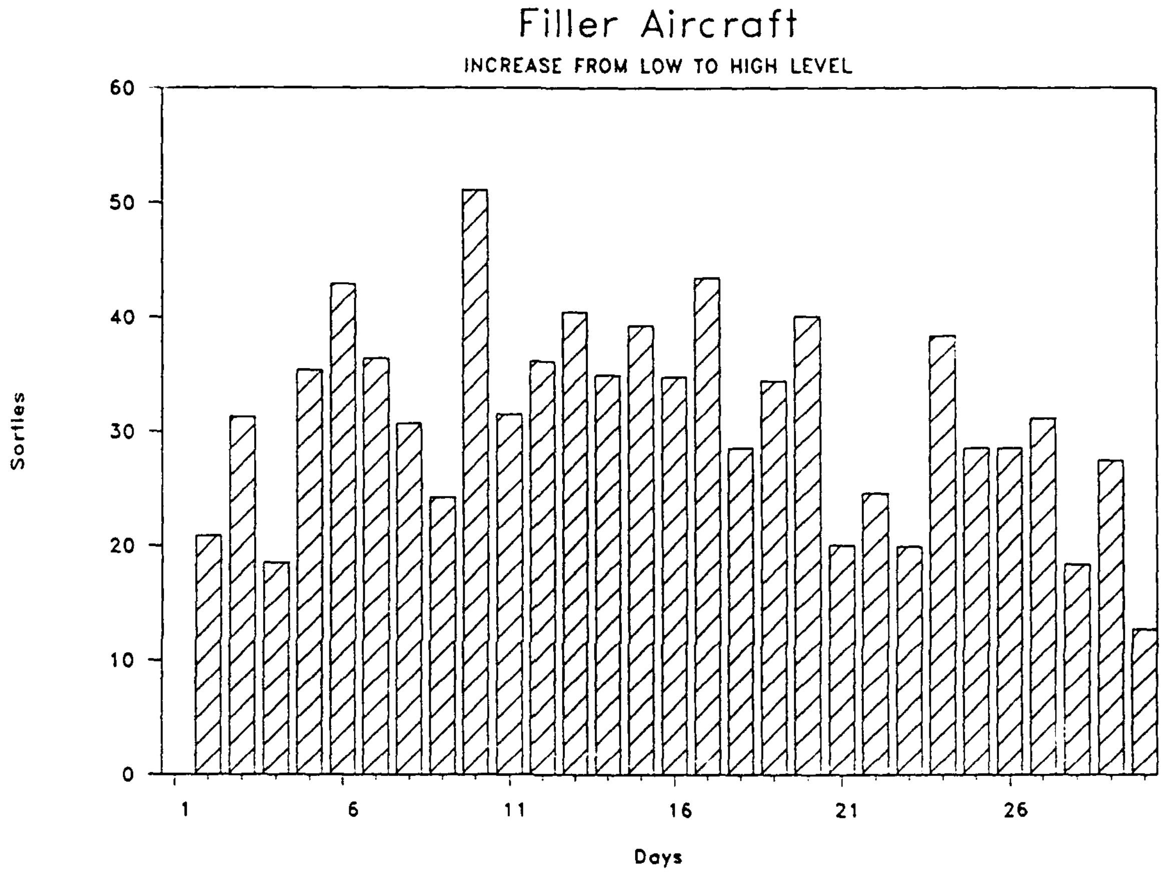


Figure 5.43

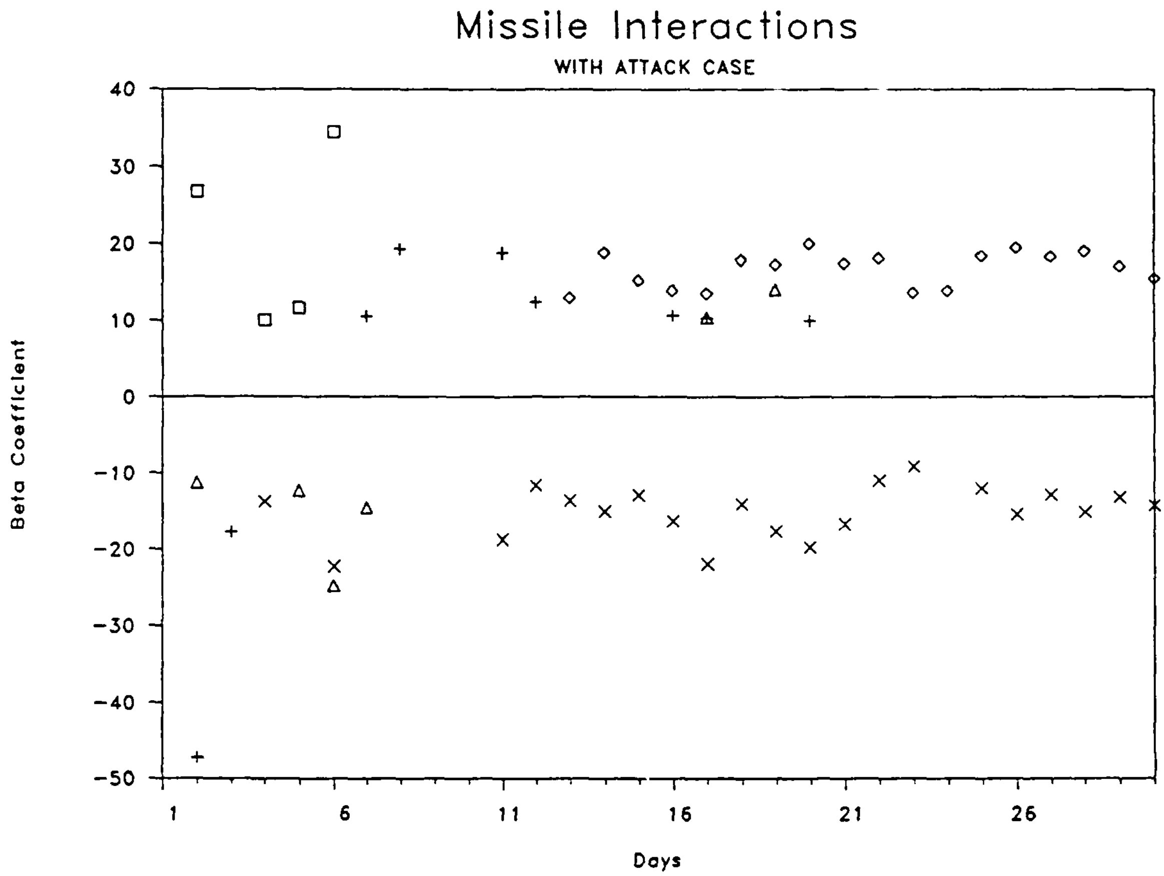
Attack Case -- Overall Contribution of Filler Aircraft contributions to sorties flown, averaging about 30 additional sorties per day. Fillers appear to be most beneficial when combined with the resources to support and fly them.

Main Effect: Missiles

Missiles are important early positive contributors as seen in Figure 5.31. Their availability allows more flyable aircraft to be launched on combat missions. However, Missiles also has important two-way interactions with other main effects which complicate the effect on sorties.

Important Interactions. Figure 5.44 depicts several interactions with Missiles. The Missile x Spares interaction has negative coefficients in the first week which means more sorties were launched with subsequent losses during the higher attrition periods. The Missile x Fuel interactions are negative and very predominant after Day 10, ranging from -9 to -22 sorties per day. This appears to be from the early flying, but is offset when the positive Missile x Personnel interaction is also present. This interaction term is discussed above as is the Missile x ABDR term.

Net Effect and Summary. Overall the Missile main effect has both positive and negative aspects when the complex interactions with other main effects are also considered. Figure 5.45 shows the overall net effect is positive after Day 7, however, two very large negative contributions are



□ missiles ◇ missile x personnel △ missile x spares
\+ missile x ABDR x missile x fuel

Figure 5.44

Attack Case -- Missile Interactions

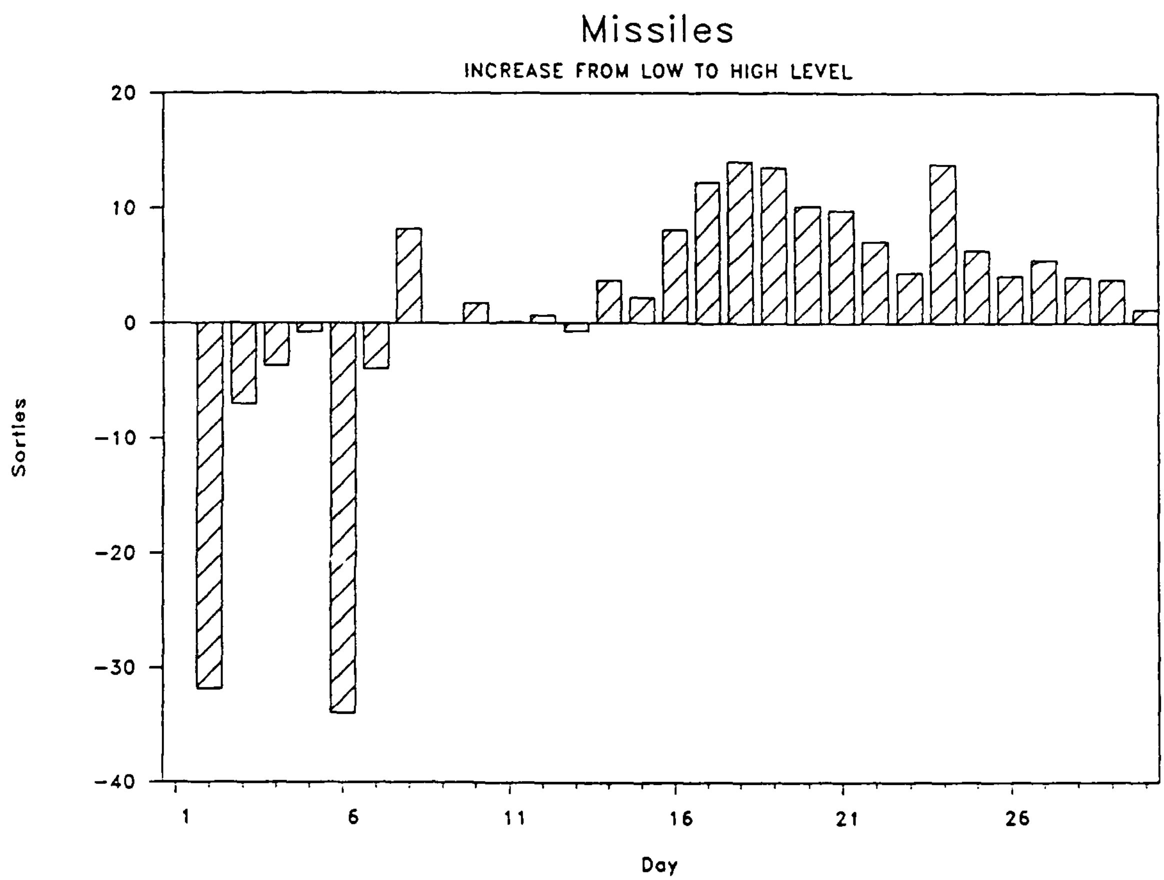


Figure 5.45

Attack Case -- Overall Contribution of Missiles found in the first week. Again there appear to be many complex interdependencies.

Main Effect: Support Equipment (SE)

Support Equipment contributes positively in almost every daily metamodel after Day 4 (see Figure 5.30). These equipment are necessary to repair and service aircraft for flight, and having more available leads to more sorties flown. SE does interact with other main effects with some positive and some negative results.

Important Interactions. The important SE interactions are shown in Figure 5.46. The SE x Fuel interaction is positive since more fuel trucks are available in the high level of SE which means the high levels of fuel available can be transferred to flyable aircraft. This then leads to more sorties. We notice too that almost all of these interactions are not significant until Day 15, which is when the first difference in the high and low levels of Fuel occurs. In contrast, SE interactions with AIS and Personnel generally are negative in the last two weeks. The high levels allow more flying early at the expense of later flying. SE x AIS did have positive contributions for three days in the first week; this probably helped result in negative coefficients later.

Net Effect and Summary. In Figure 5.47, we see that the net effect of SE over time is very much positive. The

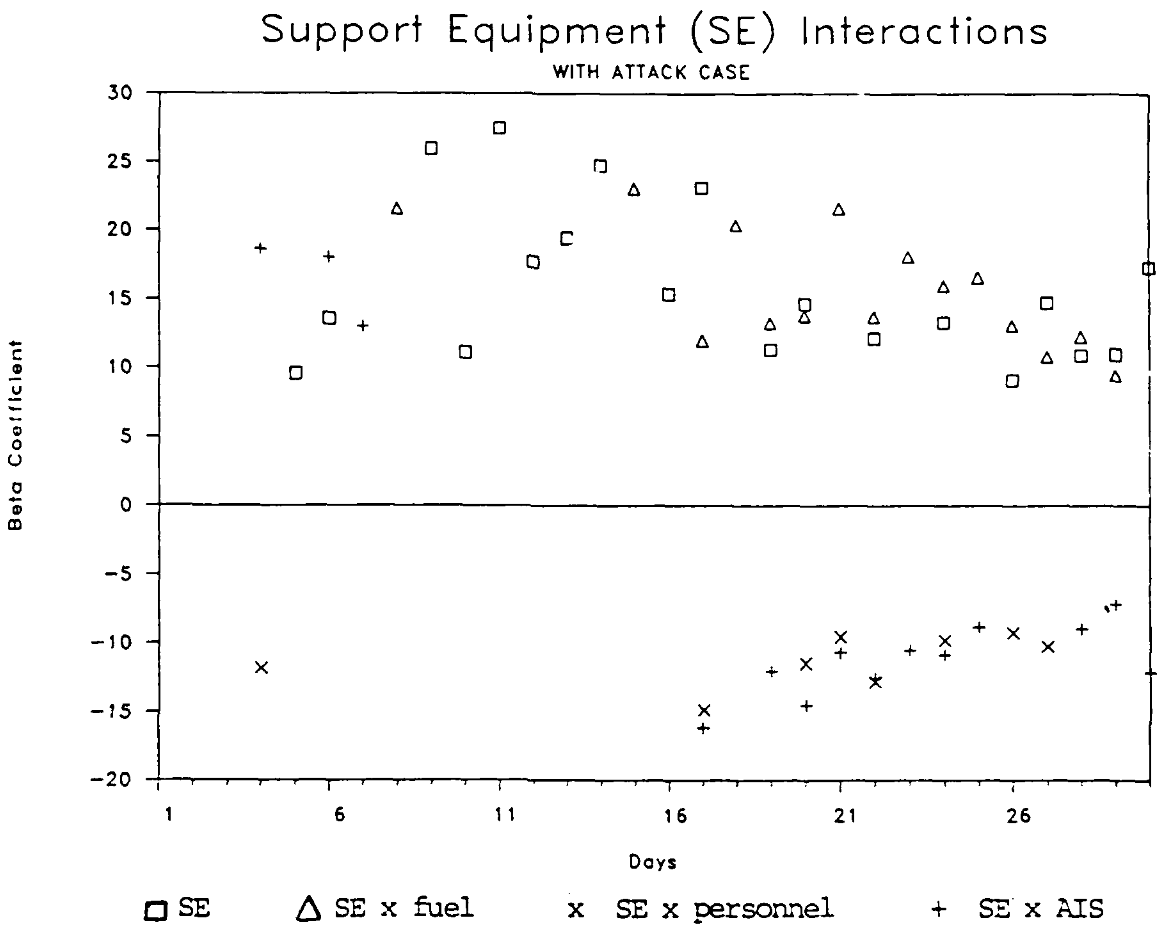


Figure 5.46

Attack Case -- Support Equipment Interactions

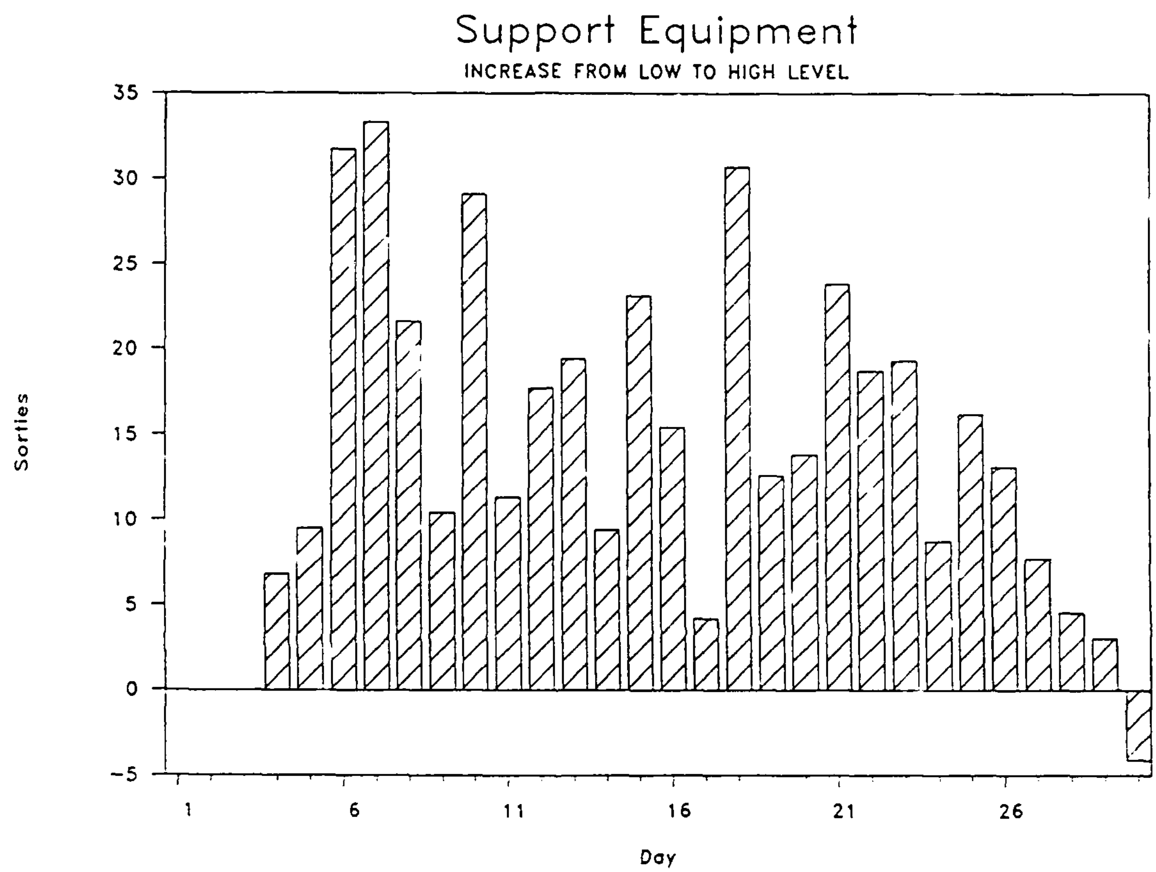


Figure 5.47

Attack Case -- Overall Contribution of Support Equipment benefits appear to outweigh the negative contributions from some of the interaction terms. These results are what we would expect from this resource. A delay in the contributions is also evident in Figure 5.47, suggesting that the attacks may destroy SE, thus making the high starting resource level important to the sortie generation effort.

Other Main Effects: Spares and AIS

Even though Spares only shows up as significant in five daily models, it interacts significantly with several other factors. Similarly, AIS is never significant in any daily metamodel, but it too has important interactions. These interaction terms are discussed below.

Spares interactions are shown in Figure 5.48. The interactions with Fillers and AIS result in very consistent positive contributions to sorties flown through much of the 30-day period. These generally reflect more parts and components available to repair aircraft so they can fly. On the other hand, Spares interactions with Fuel and Missiles result in negative coefficients. These offset the positive contributions and may result from early flying at the expense of later sorties. The net effect of having a high level of Spares is shown in Figure 5.49. The positive contributions outweigh the negative for the most part. Only three days have negative contributions and these are relatively small. Some early positive contributions are seen in the first three

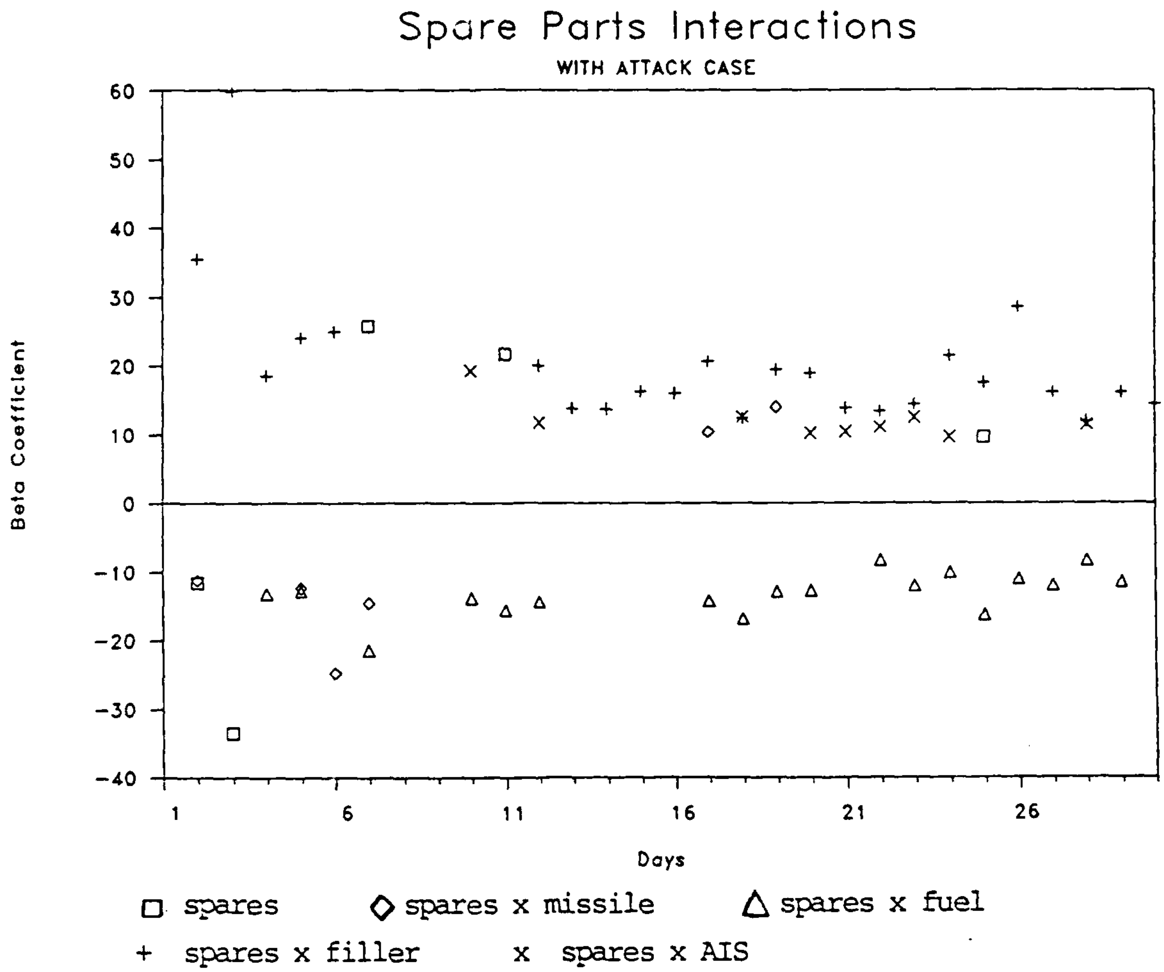


Figure 5.48

Attack Case -- Spare Part Interactions

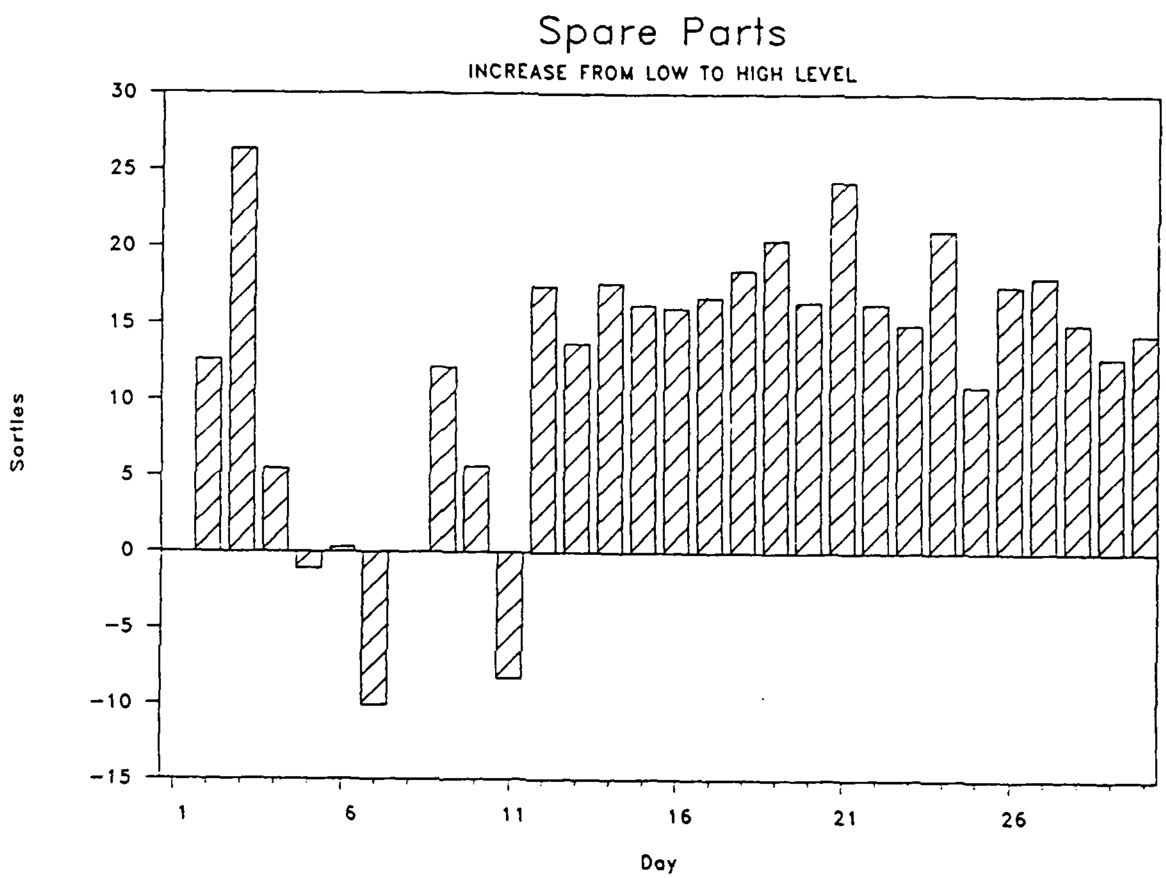


Figure 5.49

Attack Case -- Overall Contribution of Spare Parts days, however after Day 11, Spares at the high level appear to be worth about 15 sorties per day.

AIS interactions are shown in Figure 5.50. Here we see positive contributions from the interactions with Fuel and Spares. These occur entirely after Day 10. As is often the case, we have another interaction term that contributes negatively, thus partially offsetting the positive interaction terms. The AIS x SE interaction is negative after Day 16, although it did have positive coefficients in three models during the first week. The net effect of having the high level of AIS is mostly positive, as shown in Figure 5.51. Most of the benefit is expected after Day 10 and averages 9-10 sorties per day. Only three days show negative results and these are small (all less than 4 sorties per day).

Key Resources Over Time

The fourth research objective is to identify key resources and/or interactions over a thirty-day time period with and without air base attack. To make this assessment we first compare the contributions of each factor separately for the attack and no-attack cases. Table 5.1 depicts the net additional sorties flown over thirty days when each factor is at the high level as compared to the low level (with all other factors at the high level). These net totals are based on the metamodels and include significant two-way

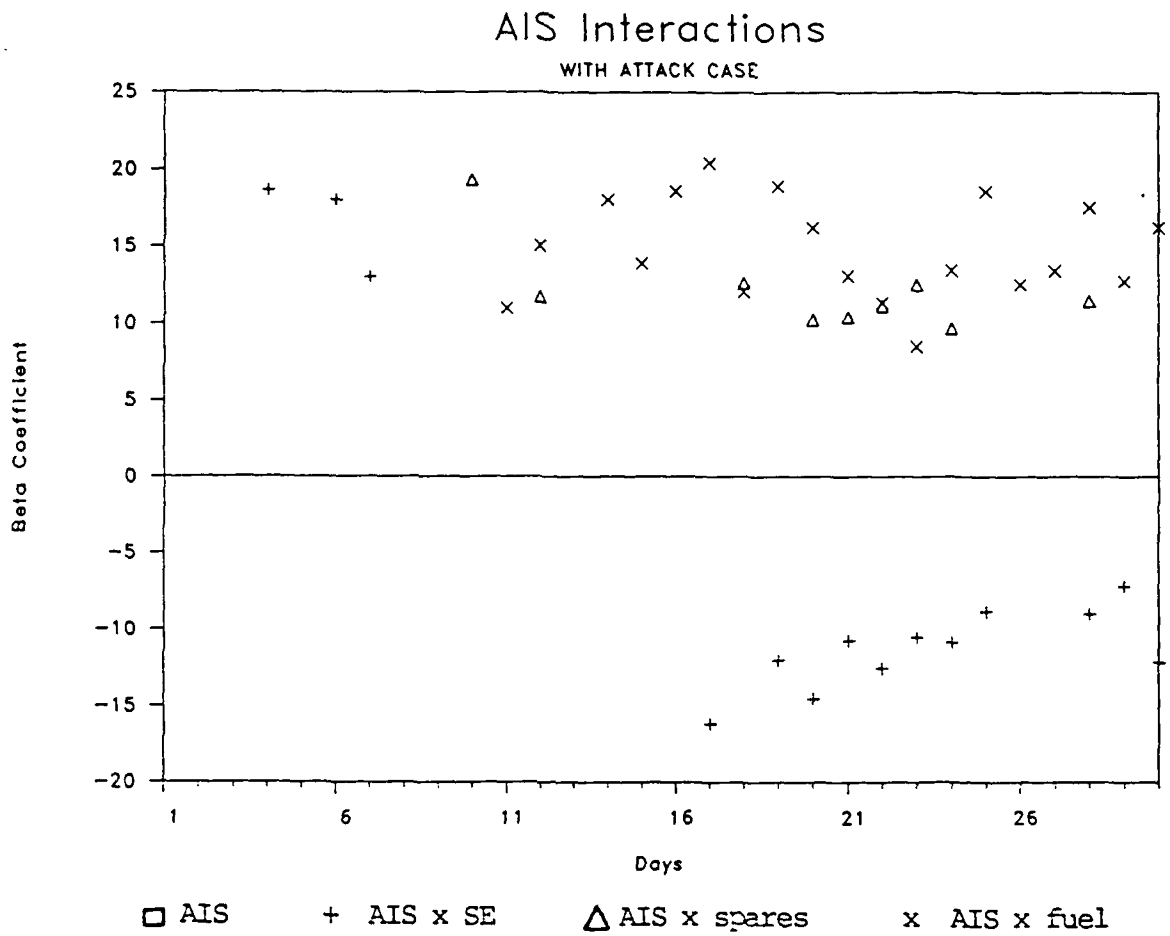


Figure 5.50

Attack Case -- AIS Interactions

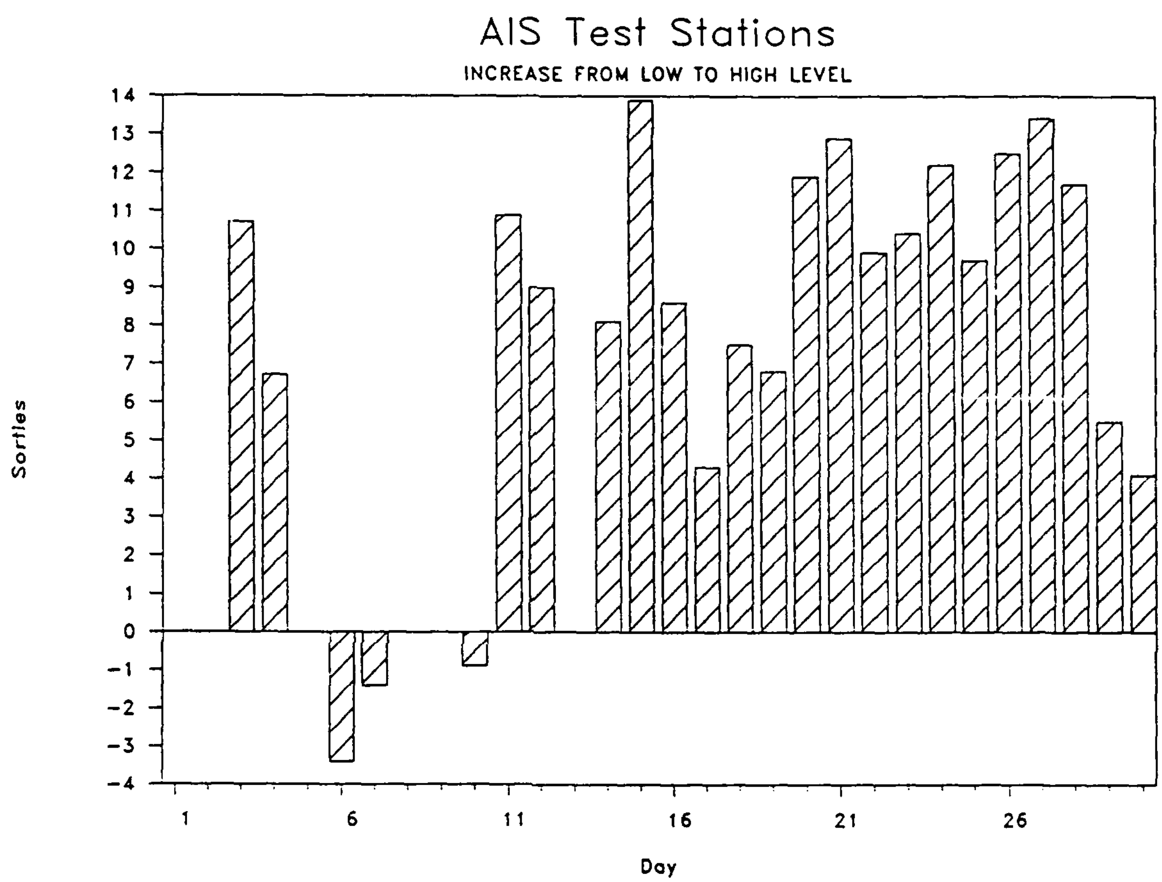


Figure 5.51

Attack Case -- Overall Contribution of AIS

Table 5.1

Net Sorties Over 30-Days for Factor at High Level Versus Low Level

FACTOR	ATTACK CASE	ABSOLUTE VALUE RANK	NO ATTACK CASE	ABSOLUTE VALUE RANK
Attrition	-114.9	6	78.2	5
Fillers	905.7	1	834.1	1
ABDR	45.7	9	40.4	8
Recovery	147.2	5	24.8	9
Personnel	85.8	7	59.0	6
AIS	195.0	4	-7.7	10
Support Eq	410.9	2	41.3	7
Spares	361.0	3	94.6	4
Missiles	52.7	8	248.3	2
Fuel	-28.4	10	245.8	3

interactions of the factor with other main effects. We examine each case separately and the comparative contributions of each factor in order to determine which are the most important over the thirty-day period. From these comparisons we will then form some conclusions as to the most important factors over time when the probability of attack is unknown.

Factor A: Attrition

Attrition seems to have opposite effects on sortie performance depending on whether or not the air base is attacked (see Figure 5.52). The attack case has a very definite negative pattern, while the no-attack case reveals a generally positive effect. In general, the contribution of Attrition in the attack case is positive as in the no-attack case, but its interaction with Fuel is negative and hence the overall negative contribution. Further evidence of the opposite effects is seen in the net totals for the two cases in Table 5.1: -114.9 sorties for the attack case compared to +78.2 sorties for the no-attack case.

Summary. Attrition is, for the most part, an uncontrollable environmental factor. Its impact on sortie performance ranks in the middle as compared to the other factors in Table 5.1. It appears that the effect of attrition is unpredictable, or at least unstable, in an uncertain environment.

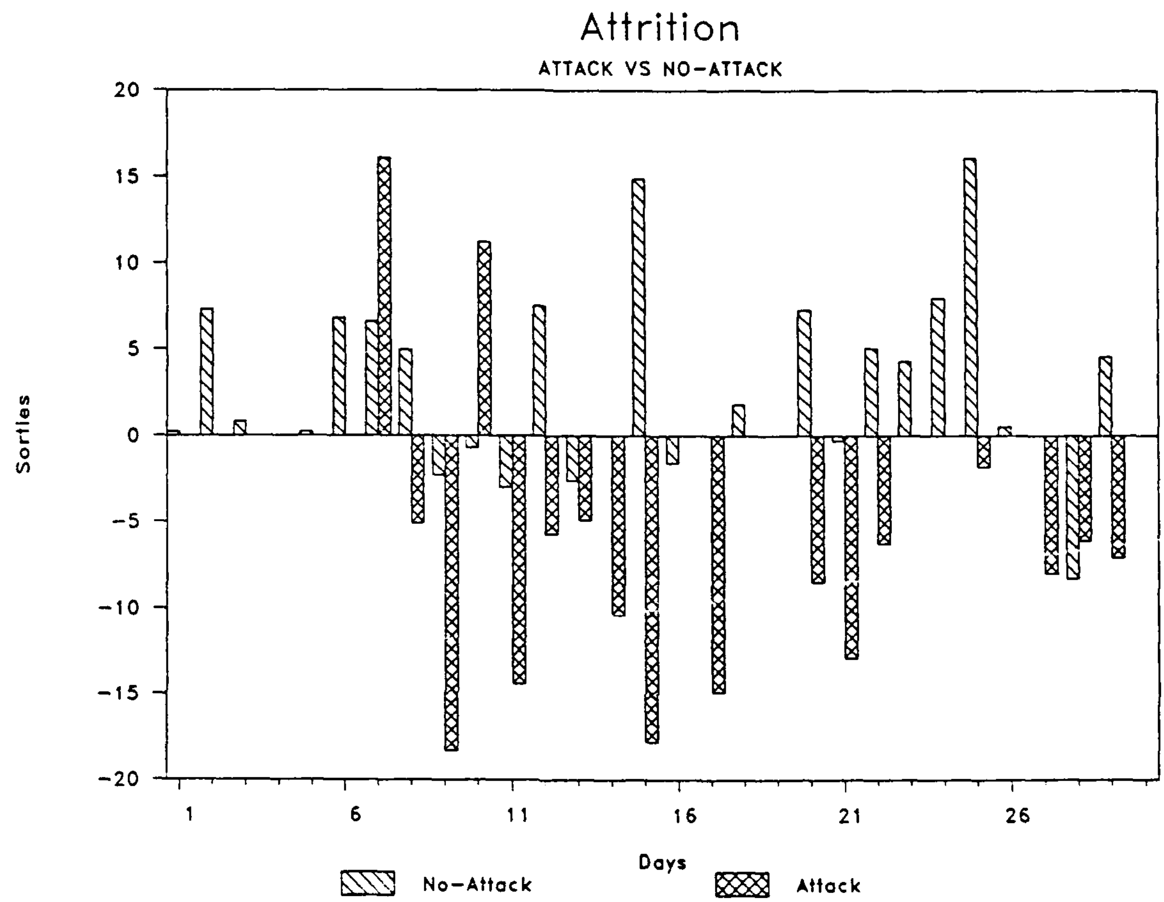


Figure 5.52

Overall Contribution of Attrition -- Attack Versus No-Attack

Factor B: Filler Aircraft

Replacement aircraft have the same positive effect for both cases. It is the greatest contributor to sortie generation in terms of net sorties (see Table 5.1) with and without attacks. In Figure 5.53, the effect of fillers occurs earlier in the attack case because aircraft destroyed in the attacks are being replaced in addition to attrition losses. The contributions are fairly large: 28-30 sorties per day on average over the thirty days regardless of attacks or not.

Summary. Filler aircraft appear to be by far the most significant contributors to sortie performance.

Factor C: ABDR

ABDR has similar results for both cases as shown in Figure 5.54. Generally the effects move in the same direction although the timing is sometimes different for the two cases. Overall, the net effects for both cases are small, 40 to 45 sorties over the thirty-day period.

Summary. Overall the difference in performance between the high and low levels is small. Relative to the other factors (see Table 5.1) the high level of ABDR does not appear to make a very significant contribution to sortie performance beyond that provided by the low level of capability.

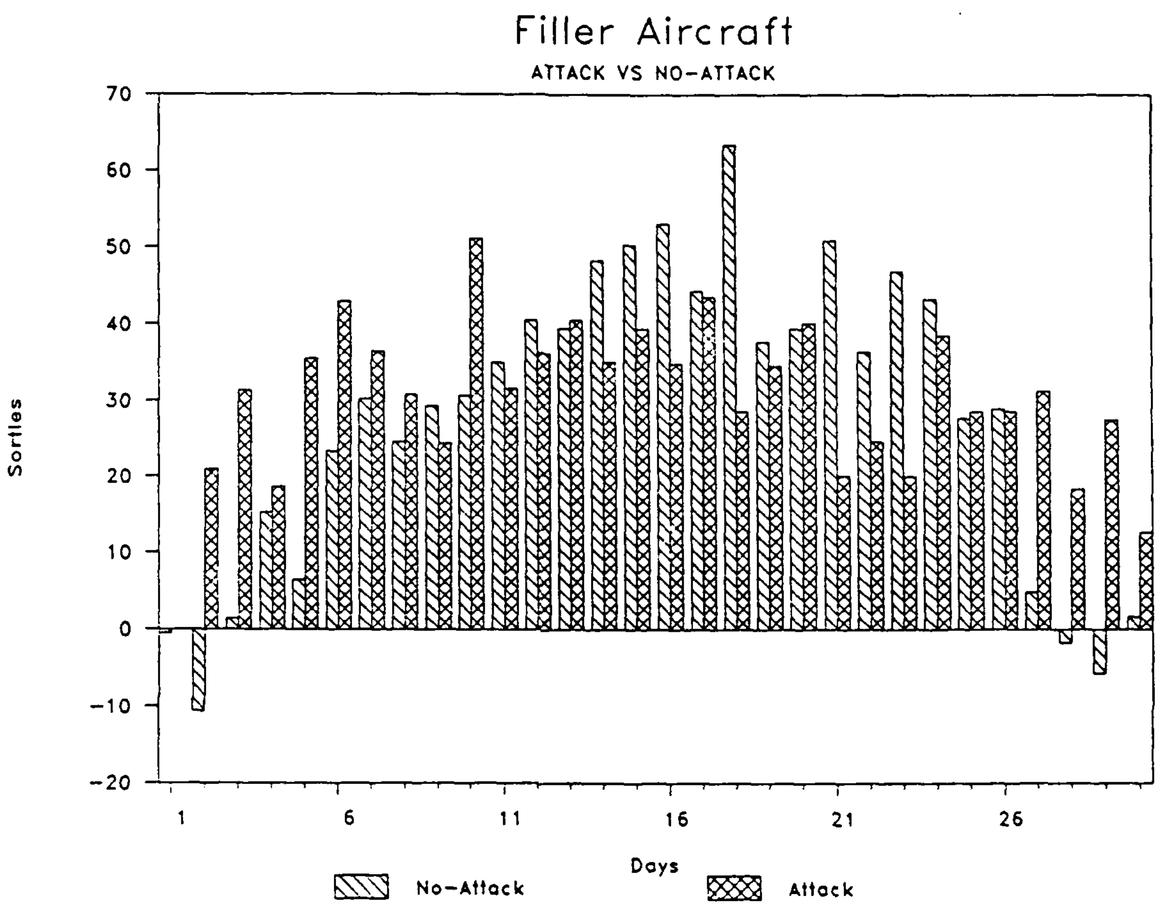


Figure 5.53

Overall Contribution of Filler Aircraft -- Attack Versus No-Attack

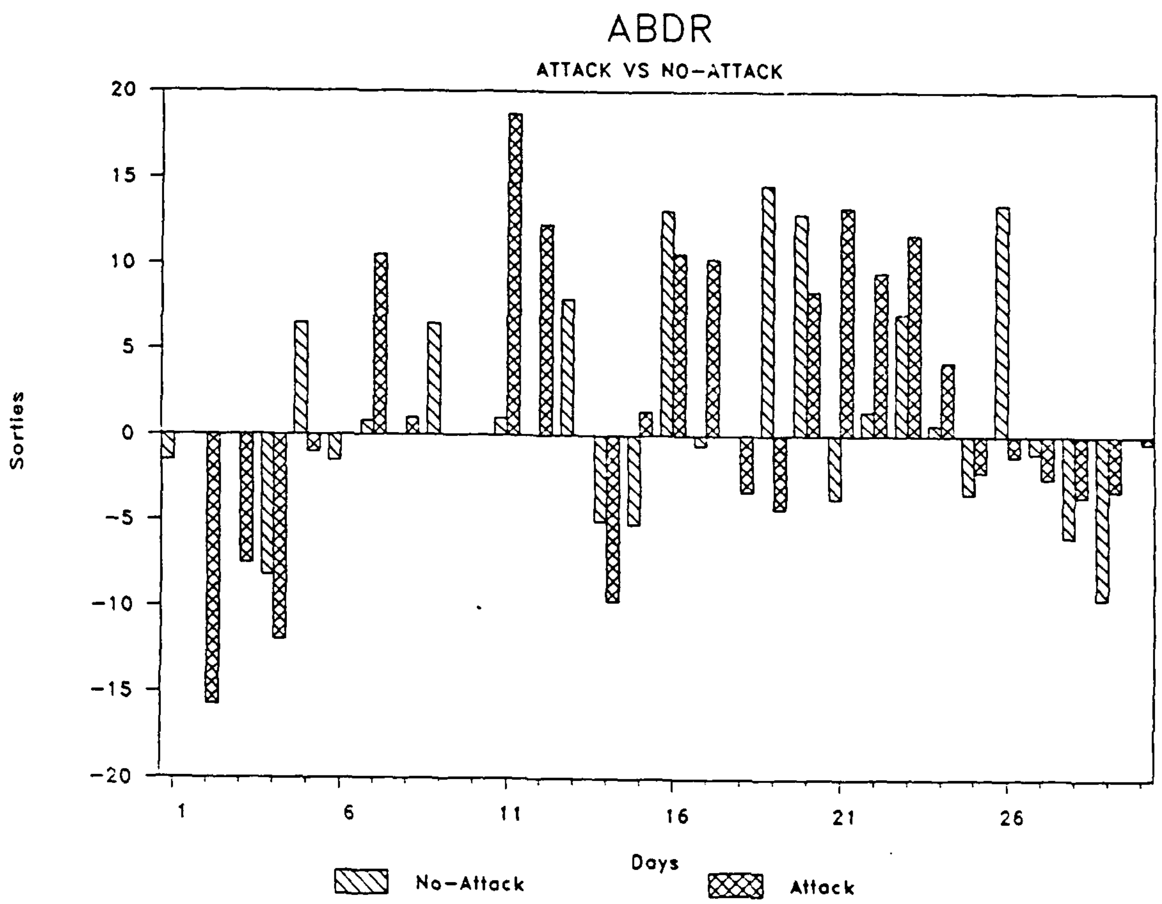


Figure 5.54

Overall Contribution of ABDR -- Attack Versus No-Attack

Factor D: Recovery Resources

As expected, recovery resources are only important when the air base is attacked as can be seen in Figure 5.55. Large positive contributions are made during the period of attacks with net sorties of +147.2 expected over the thirty days (Table 5.1).

Summary. The impact of additional recovery capabilities is evident during the attack period. A central issue concerns the value of these additional sorties. The early time period of a war may be very crucial and our ability to keep flying during this time may decide the eventual outcome of the war. Thus, although the recovery factor is not significant throughout the entire period, it might very well be one of the most significant factors if early sorties are indeed the most valuable sorties.

Factor E: Personnel

Personnel's contribution to sortie generation generally follows the same pattern in both cases. However, as seen in Figure 5.56, the effects in the absence of attacks are more pronounced. In the early part of the thirty-day period, there are high sortie demands where many technicians are needed to fix and service aircraft. In the attack case, the high sortie rates demanded cannot be met because runways are damaged and closed. Therefore the workloads are reduced and the contribution of additional people is not as great. Table

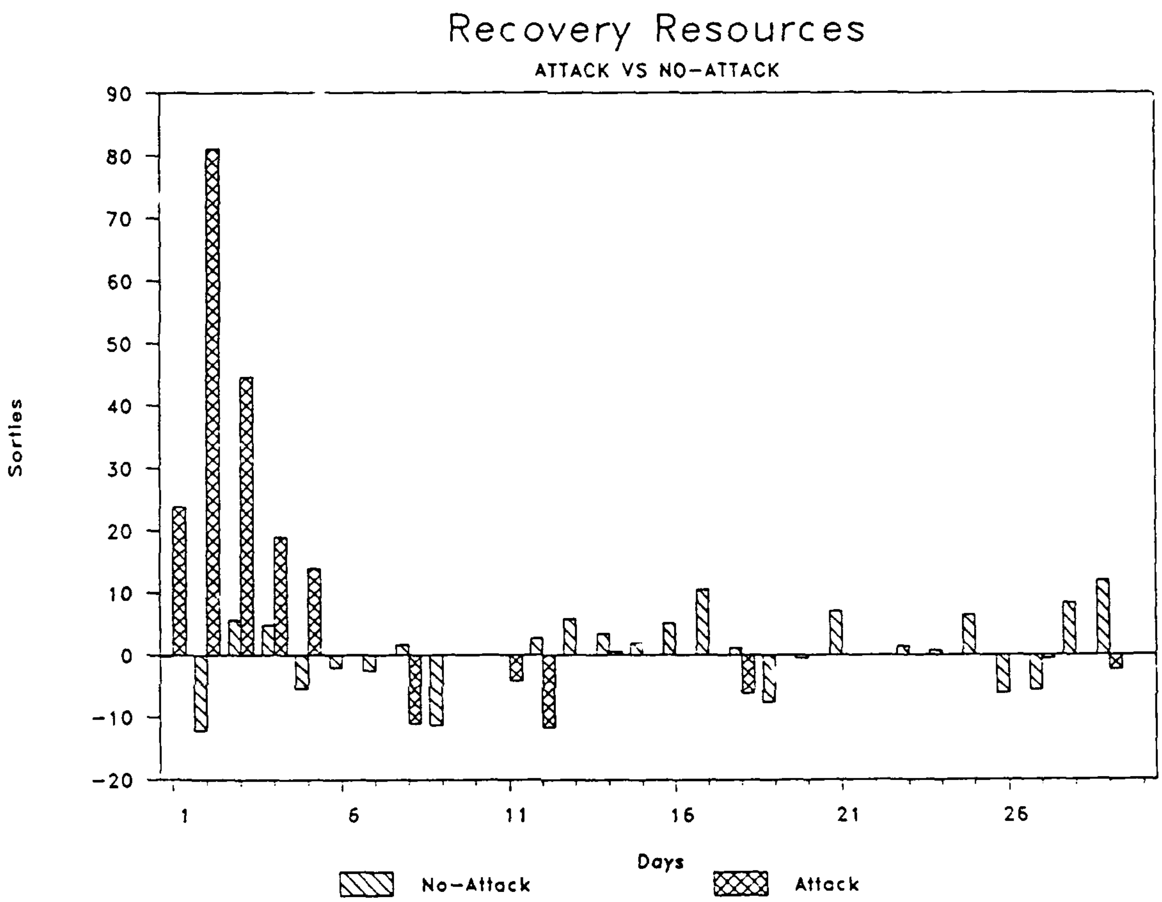


Figure 5.55

Overall Contribution of Recovery Resources -- Attack Versus No-Attack

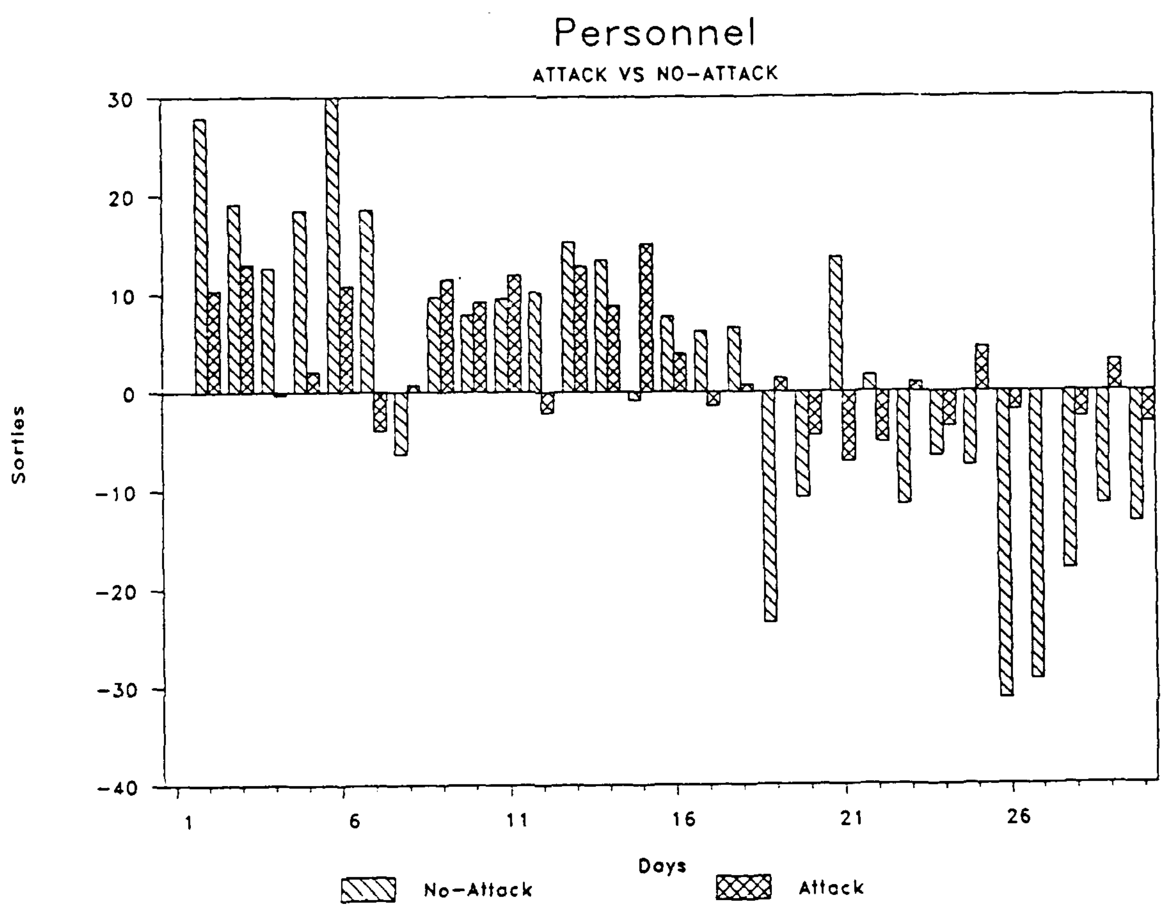


Figure 5.56

Overall Contribution of Personnel -- Attack Versus No-Attack

5.1 shows that the net contribution of people in either case is not very great. This result is counterintuitive and is due primarily to negative contributions in the last half of the thirty-day period which offset the earlier gains of having a high level of Personnel.

Summary. People appear to be most important when there are no other restrictions on the flying effort. Thus, in the absence of attacks which prevent flying to a large extent, people are significant contributors when at the high level as opposed to the low level. We also note that there appear to be significant penalties in later days due to the added sortie generation capability in the early days.

Factor F: AIS Test Sets

During the first fifteen days in Figure 5.57, we generally see the same directions for contributions to the sortie effort. After that, we see opposite effects, with positive contributions when attacks are present, and negative contributions in the absence of attacks. This indicates that the effect of the attacks is important. Possibly parts are destroyed by the attacks which increase the reliance on the AIS to repair malfunctioning components. Ordinarily a replacement part would be in stock and used to repair the aircraft, thus shortening the time the aircraft is unflyable. In this case, since fewer parts are available due to the attacks, inoperable avionic components are removed from the

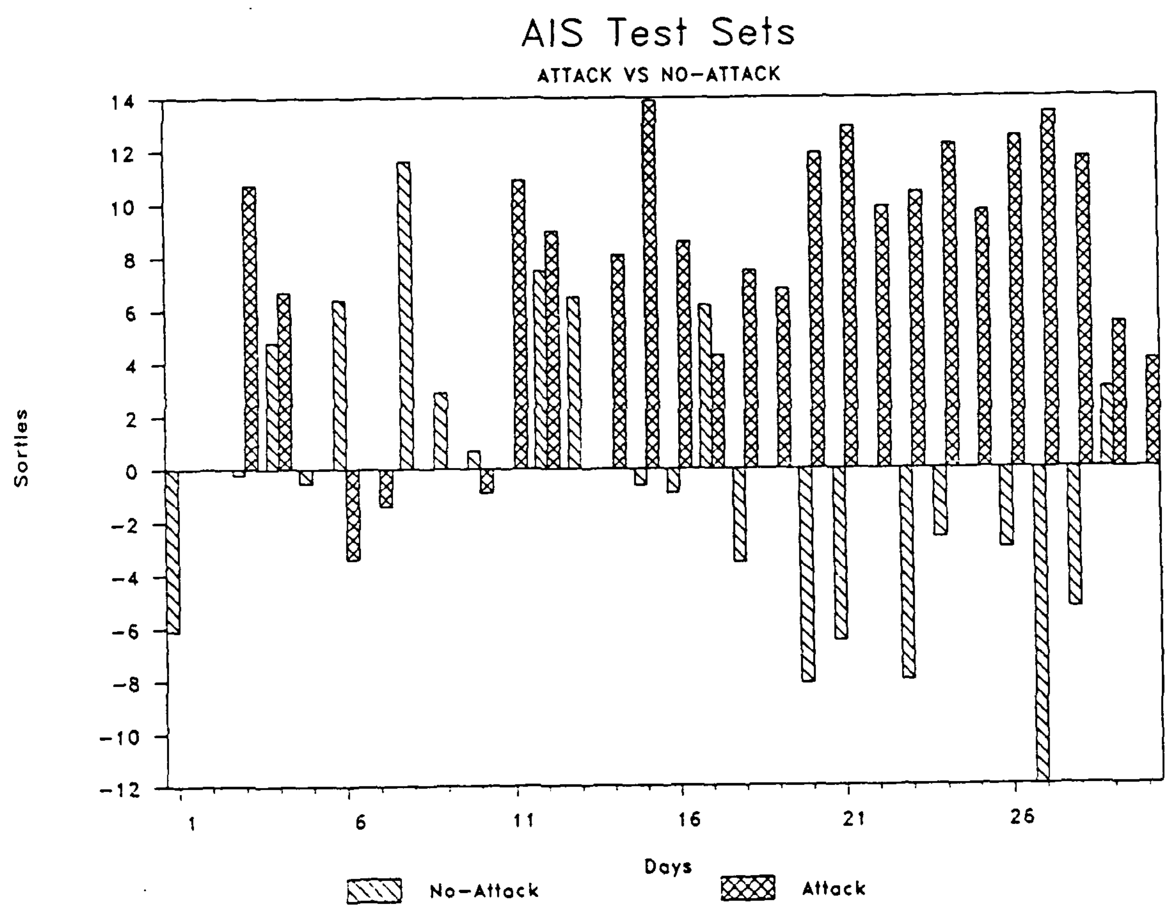


Figure 5.57

Overall Contribution of AIS -- Attack Versus No-Attack aircraft, repaired on the AIS, and returned to the aircraft. Thus, the greater the AIS repair capability, the shorter the downtime for the aircraft. A second possibility is that the attacks damage the AIS itself. Here the availability of two sets (the high level) increases the likelihood that some AIS capability will be present even if damage occurs. Overall in Table 5.1, the net sorties gained from AIS is fourth when attacks occur, but ranks last in the absence of attacks.

Summary. Overall, AIS and its interactions account for 6-7 sorties per day on average over the thirty-day period when attacks are present. Thus the contribution appears to be fairly small with little gained by having two sets instead of one, especially in the no-attack case.

Factor G: Support Equipment

While fairly unimportant in the no-attack case, support equipment is the second highest net contributor over the thirty-day period when attacks are present (see Table 5.1 and Figure 5.58). This suggests that support equipment are destroyed in the attacks which has a significant impact on subsequent repairs, servicing, and flying. This impact averages 13 sorties per day over the entire in the attack case.

Summary. The benefits of the high level of support equipment is evident in the attack case, while the low level appears to be sufficient in the no-attack case. Thus it

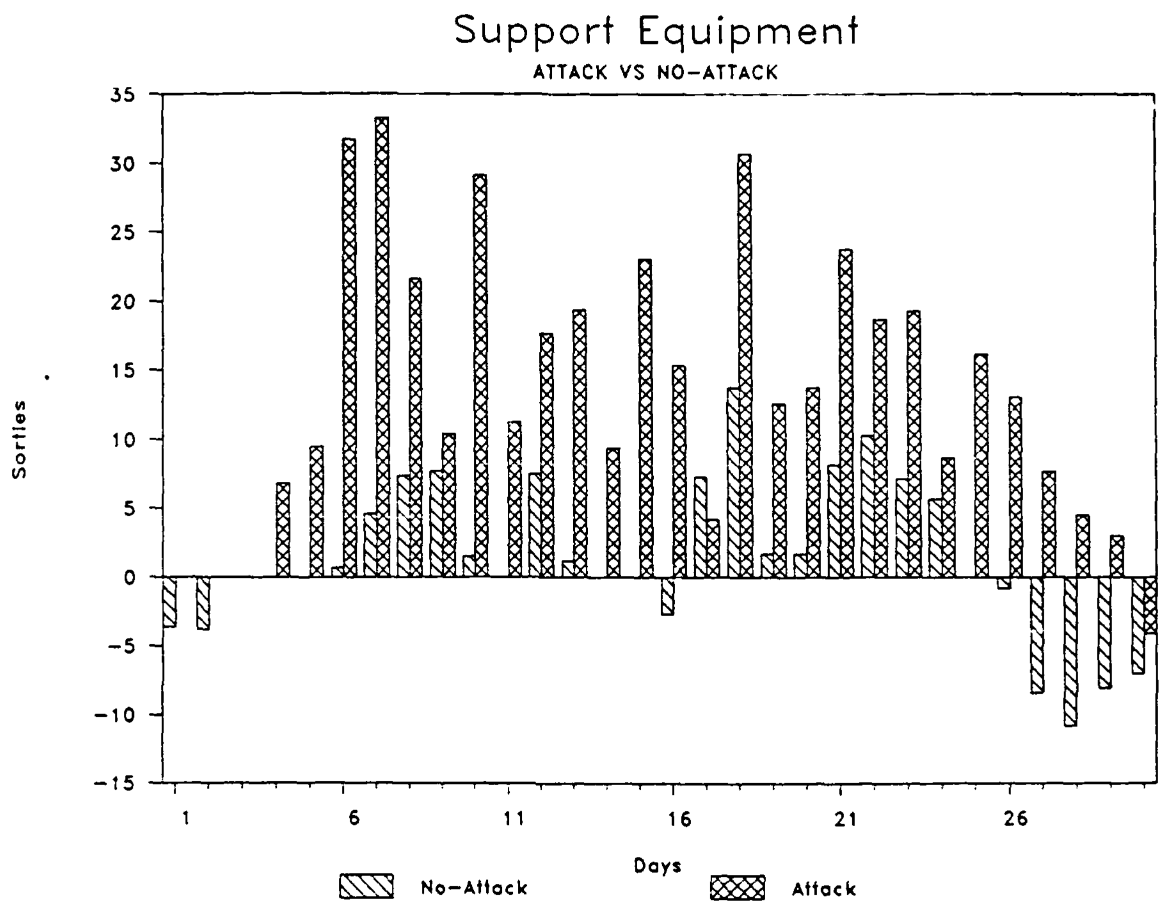


Figure 5.58

Overall Contribution of Support Equipment -- Attack Versus No-Attack seems that adequate protection of support equipment is very important. Assured protection may allow a lower level of equipment to suffice rather than procuring more.

Factor H: Spare Parts

Figure 5.59 shows that the attack and no-attack cases have generally the same results for Spare Parts until the last five days of the thirty-day period. Spares, high level versus low level, appear to be more important in the attack case, averaging an expected +12 sorties per day over the entire period. The higher level of spares means a greater likelihood of having parts available for repairs despite losses during the attacks. In terms of net sortie contribution over thirty days, spares is the third most important resource in the presence of attack and ranks fourth when there are no-attacks (see Table 5.1).

Summary. Spares and its interactions with other main effects are important to the sortie generation effort, with and without attacks. Significant gains can be made with a high level of spares when attacks are likely.

Factor J: Missiles

Missiles are more important when there are no-attacks as is seen in Figure 5.60. Table 5.1 also reflects this, with missiles ranking number two in the no-attack case on the basis of expected net contribution to sorties over the thirty-day period. Missiles rank only eighth when attacks

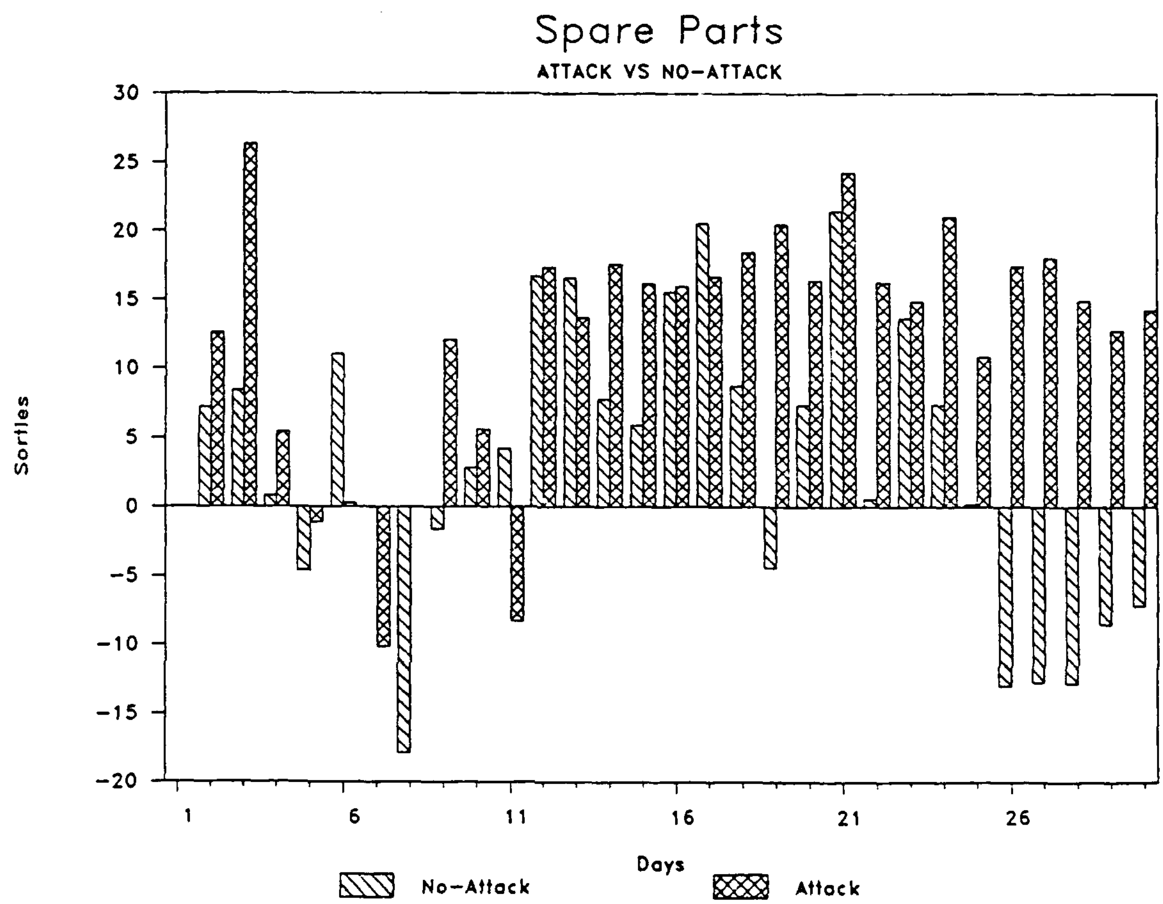


Figure 5.59

Overall Contribution of Spare Parts -- Attack Versus No-Attack

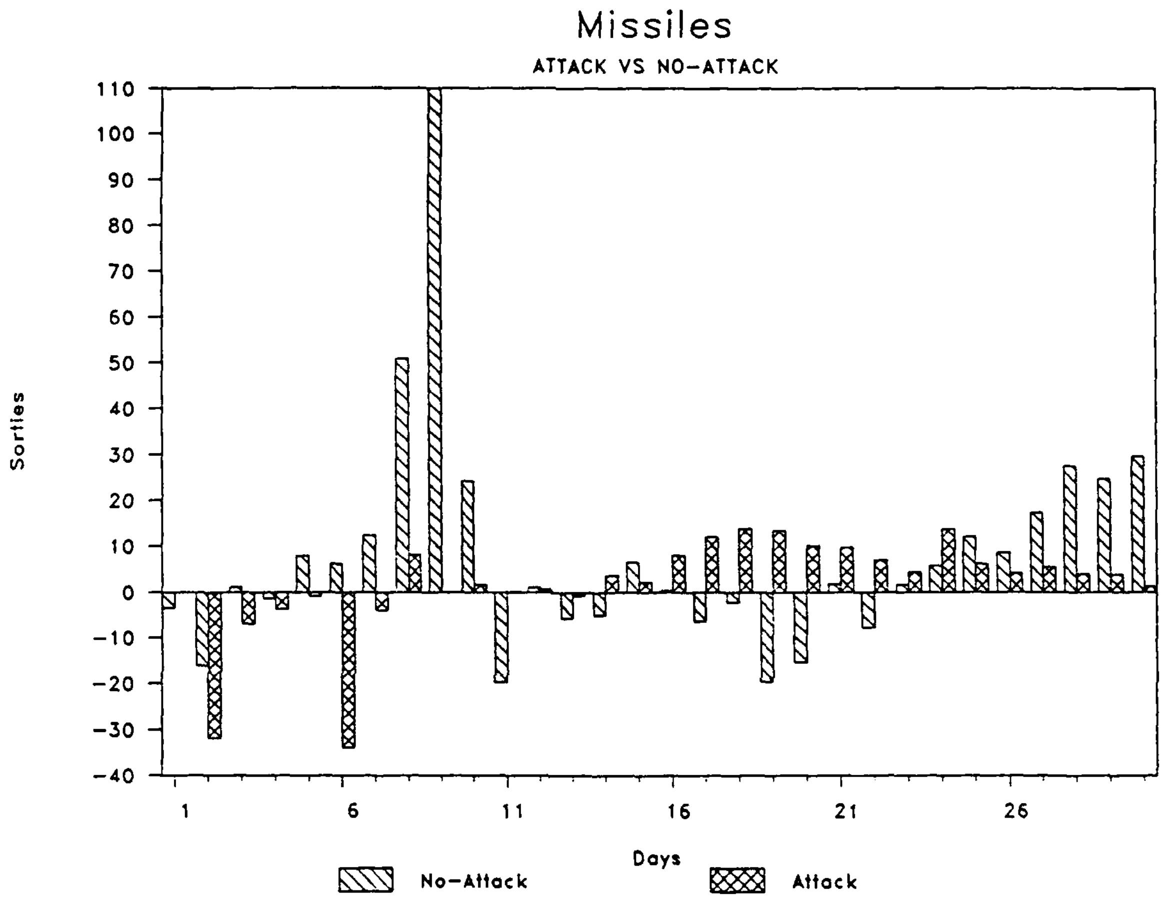


Figure 5.60

Overall Contribution of Missiles -- Attack Versus No-Attack are present. It appears that the attacks slow down flying, thus reducing the demand and consumption of missiles. When there are no-attacks, the consumption of missiles is high due to the high sortie rates being flown. We should note the very significant "spikes" on Days 8-10 in Figure 5.60 which occur because the low case is running out of missiles; the positive contributions subside because of deliveries received the afternoon of Day 10. The no-attack case has a similar positive trend at the end of the period where missiles are running out due to high flying levels and missile consumption.

Summary. Missiles appear to be most important where high sortie rates are flown. To sustain these flying demands, consumable resources such as missiles must be available.

Factor K: Fuel

The effects of Fuel on sortie generation are generally opposite for the attack and no-attack cases (see Figure 5.61). From Table 5.1, we see that fuel ranks last in importance in the attack case, but is third in the no-attack case. Fuel is another resource that is affected by high consumption rates found in the no-attack case. As seen in Figure 5.61, the expected positive contributions come mainly late in the period when a high number of sorties have accumulated thereby consuming Fuel resources. In comparison,

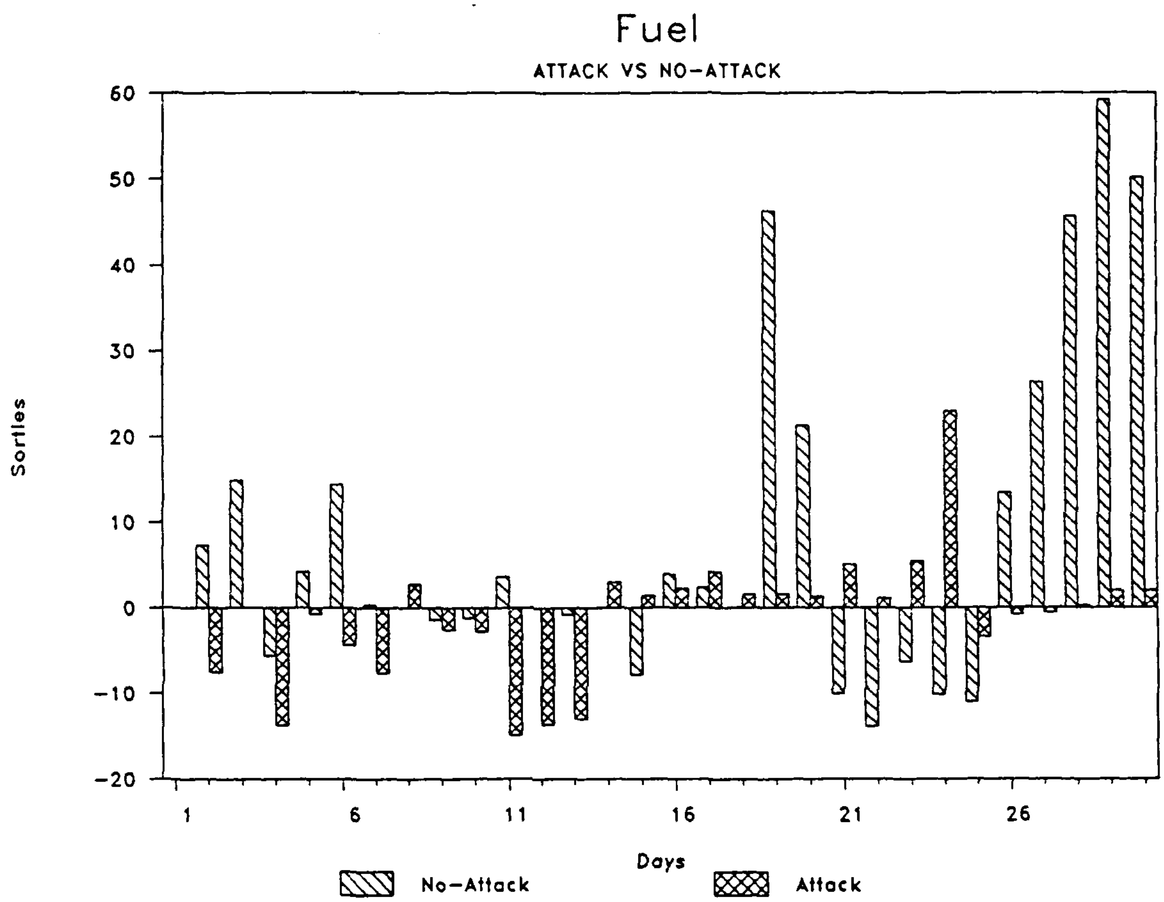


Figure 5.61

Overall Contribution of Fuel -- Attack Versus No-Attack the attacks prevent and slow the flying effort and hence the demand for fuel. Attacks do not appear to cause any significant losses of fuel stored on the air base.

Summary. Fuel is another consumable resource necessary to sustain flying at high sortie rates. Generally, the amount available in this research is sufficient until later periods where the additional deliveries provided by the high level make a difference.

Overall Importance of Factors

To determine the most important factors, we first examine the attack and no-attack cases separately. Then we judge the effects of the factors across the cases, i.e., which factors are most important given that we do not know whether or not the air base will be attacked.

Attack Case

In Table 5.1 the factors are ranked according to the expected net additional sorties over thirty days when the resource is at the high level as compared to the low level. The top five contributors are graphed in Figure 5.62 to show comparatively which factors contribute the most per day over time. Similarly, Figure 5.63 depicts the remaining factors. From Figure 5.62, it is obvious that Filler Aircraft is the dominant factor across the period. Support Equipment is the second leading contributor across the time period, followed

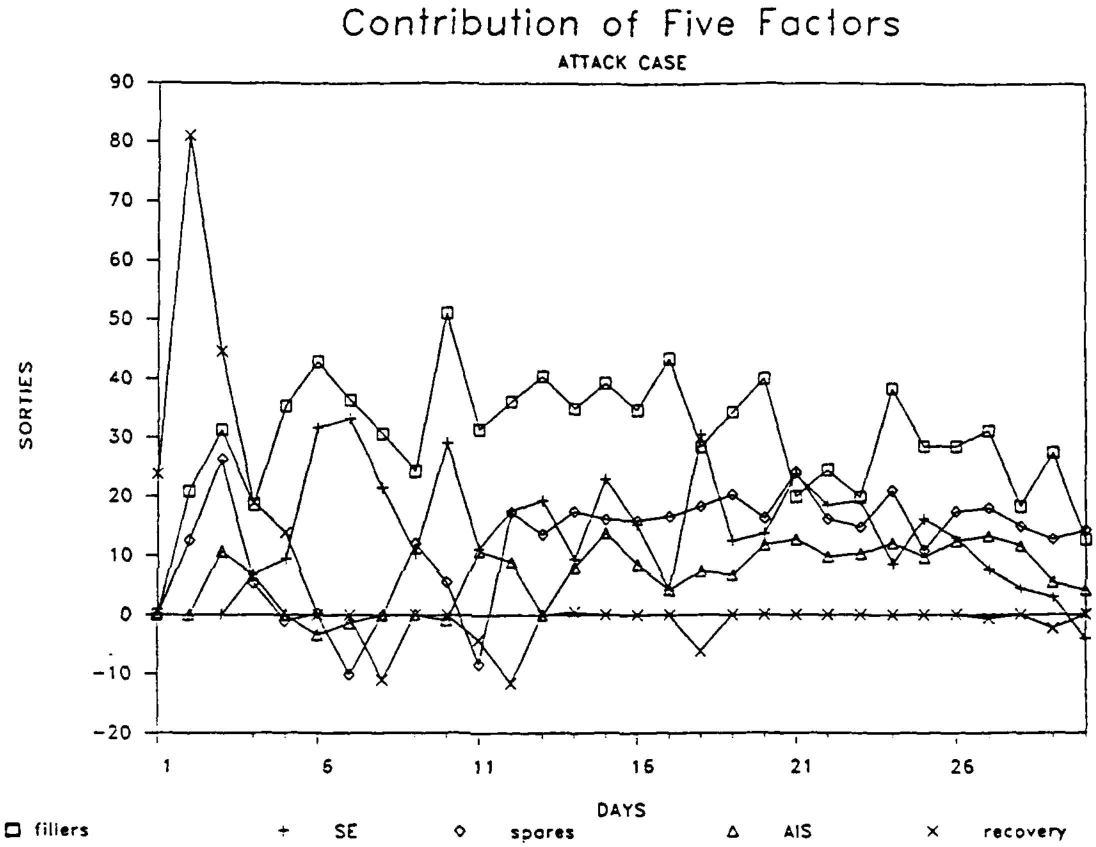


Figure 5.62

Attack Case -- Overall Contribution of Five Factors (1)

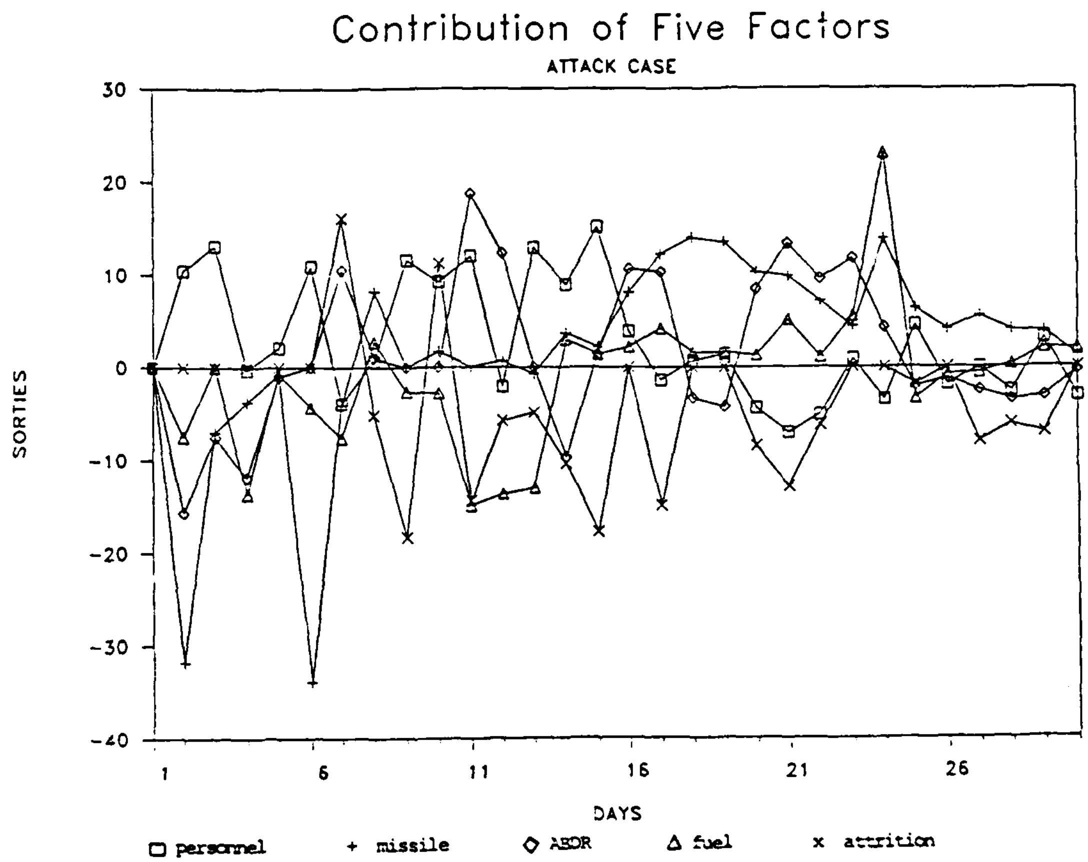


Figure 5.63

Attack Case -- Overall Contribution of Five Factors (2) by Spares whose contributions are most obvious and consistent after Day 11.

Two resources appear to be important for certain periods of time. Recovery resources makes a short-lived, but significant, contribution during the attack period, but then is negligible. Personnel, graphed in Figure 5.63, is a strong contributor primarily during the first 15 days. Both are important if the war will last a short time and/or if the value of early sorties outweighs that of later sorties. AIS makes a small but consistent daily contribution after Day 10 (see Figure 5.62). Similarly, Missiles contribute after Day 15. These observations lead to a rank-ordering of the factors based on importance of contributions to sortie generation.

<u>Rank order</u> based on Table 5.1 and Figures 5.62 and 5.63 is the following:

1. Filler aircraft
2. Support equipment
3. Spare parts
4. Recovery resources
5. Maintenance personnel
6. AIS test sets
7. Missiles
8. ABDR capability
9. Fuel

This assessment is subjective and takes no account of the cost of each resource area in terms of procurement, training, and maintenance.

No-Attack Case

As we did for the attack case, the factors are ranked in Table 5.1 according to the expected net additional sorties over thirty days for the no-attack case. For consistency, the same groupings of contributors as in the attack case are used to construct Figures 5.64 and 5.65 to show comparatively which factors contribute the most per day over time. From Figure 5.64, it is obvious that Filler Aircraft, as in the attack case, is the dominant factor across the period. Although the contribution of Missiles is limited to short periods of time, the magnitude of the expected contribution is very significant. As a result, this factor is considered the second most important for the no-attack case. (NOTE: Since the magnitude of the missile contribution compresses the y-scale in Figure 5.65, this figure is redrawn as Figure 5.66 without Missiles so the remaining factors can be compared.) Similarly, Fuel is ranked as the third most important factor due to its large potential impact on sorties flown.

As in the attack case, Personnel contributes positively and significantly for the first 15 days. Because of the potential value of those early sorties, Personnel is ranked

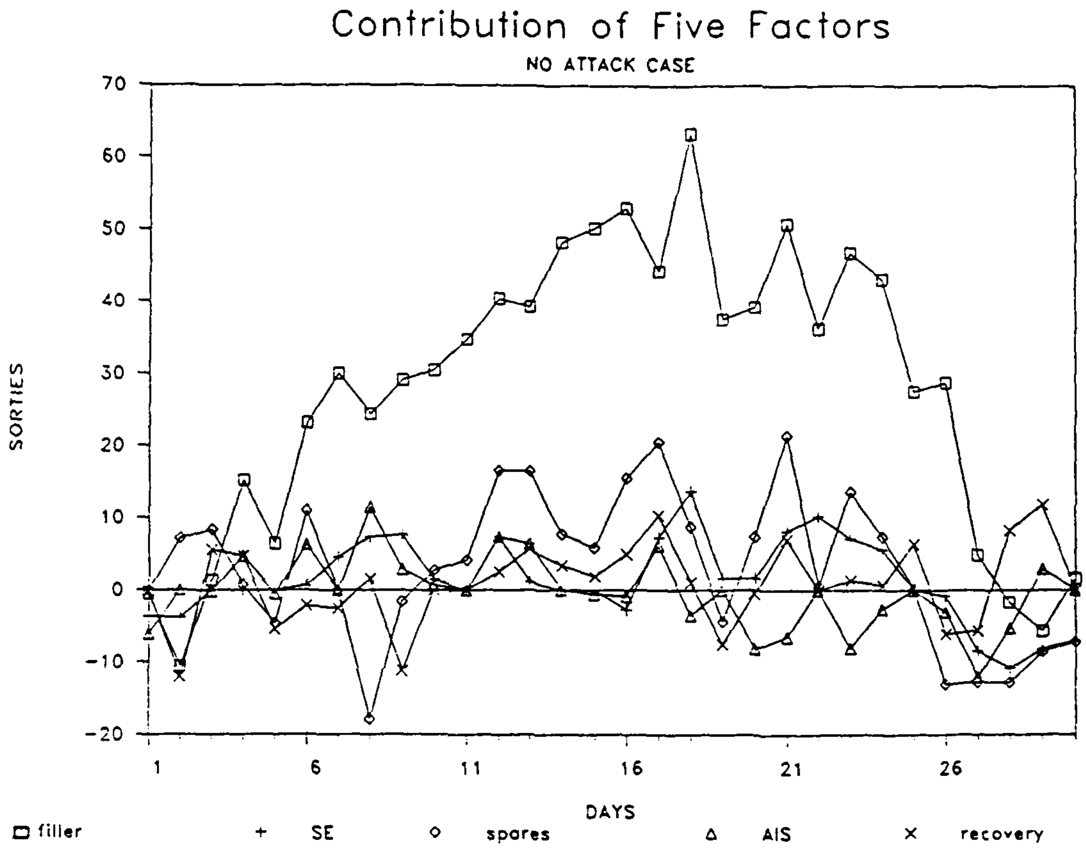


Figure 5.64

No-Attack Case -- Overall Contribution of Five Factors (1)

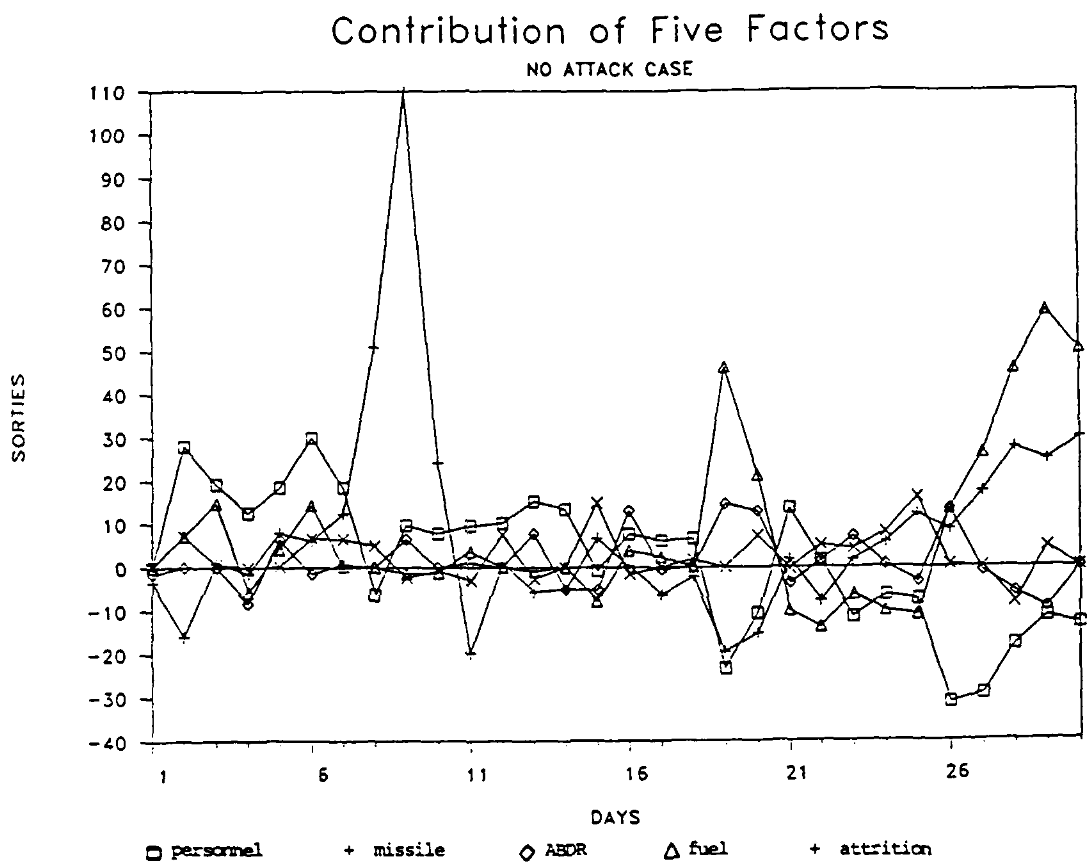


Figure 5.65

No-Attack Case -- Overall Contribution of Five Factors (2)

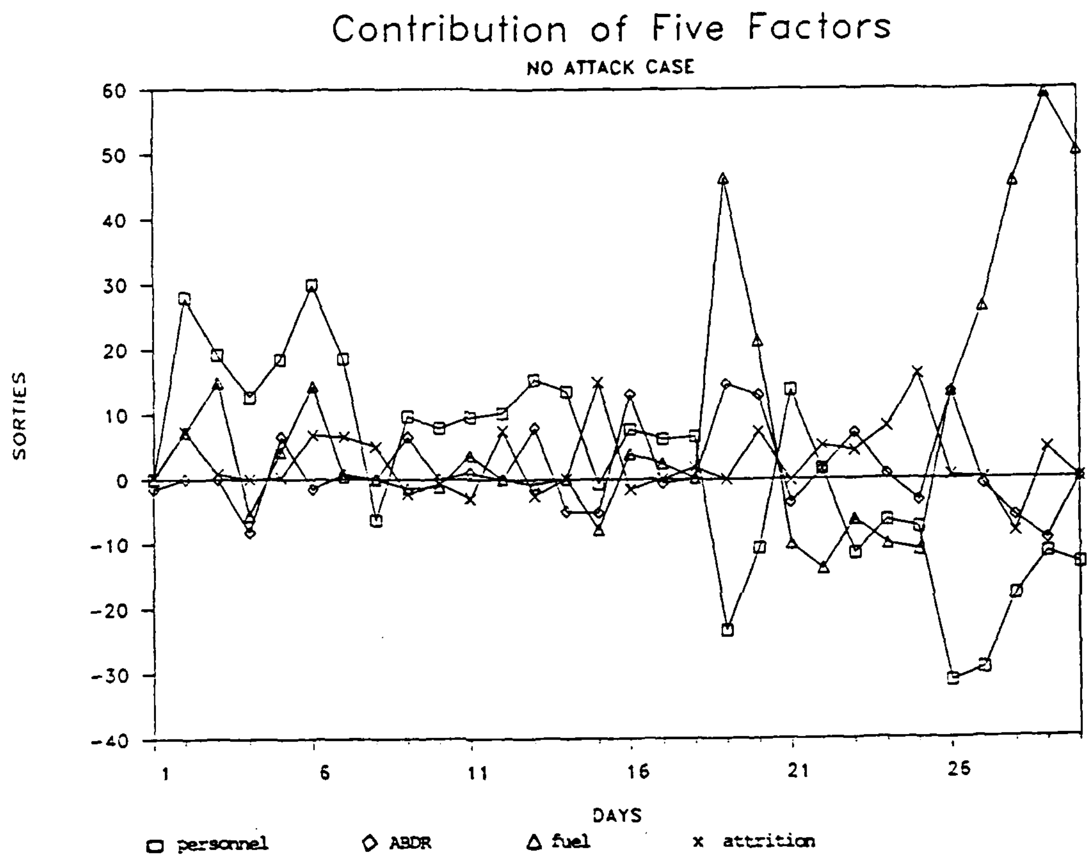


Figure 5.66

No-Attack Case -- Overall Contribution of Five Factors (2) -- Modified third for the no-attack case. Spares are ranked next with generally positive contributions throughout the period. Support Equipment contributions are rather small throughout the period, but are consistently positive except during the first two and last five days. Differences between ABDR and AIS are difficult to distinguish, while Recovery is rated last since it is not needed in the absence of air base attacks.

Rank order for the no-attack case, based on Table 5.1 and Figures 5.64 - 5.66, is the following:

1. Filler aircraft
2. Missiles
3. Fuel
4. Maintenance personnel
5. Spare parts
6. Support equipment
7. ABDR capability
8. AIS test sets
9. Recovery resources

As in the attack case, this assessment is subjective and takes no account of the cost of each resource area in terms of procurement, training, and maintenance.

CHAPTER VI - CONCLUSIONS AND FUTURE RESEARCH

From the many results presented in the two previous chapters, we now draw some overall conclusions which may be useful to logistics managers and researchers. Before discussing specific conclusions, we first define the scope of this research. Next, conclusions for each research objective are presented based on the results for that objective. Then we address some limitations of the study and finally recommend some areas for future research.

Scope

Conclusions must be within the scope of this research. The design of the experiment limits the number and type of possible valid conclusions we can draw from the results. Our simulation experiment models a single, specific air base with one type of aircraft, the F-15. As such, conclusions may not be extendable to other air bases or types of aircraft. Further, although we use eight random versions of a set of air base attacks, the attacks are constant with respect to the number of attackers, their desired aimpoints and approaches to the air base, timing of the attacks, types of munitions used, etc. A change in any of these factors could influence the results and conclusions.

A very important assumption imbedded in the entire work concerns the TSAR and TSARINA simulation models. We have assumed that the processes modeled by these simulations are accurate and realistic representations of the real world. Actually these models are also metamodels themselves of an air base's logistics infrastructure placed in a hostile environment. Thus conclusions are contingent upon the processes as modeled by TSAR and TSARINA. Given this scope, we now present some conclusions drawn from the results of this research.

Conclusions

Research Objective 1: Experimental Design

Part of this objective concerns variance reduction through the use of a statistically controlled experiment. The idea is to use techniques which reduce the variance of the output random variable from the simulation. If this can be done without disturbing its expected value, we can obtain either greater precision from a fixed number of runs, or the same level of precision from fewer runs (Law and Kelton, 1982). This can be significant especially when using large, expensive-to-run simulation models. A second part of this objective concerns designing the experiment in such a way that we can make statistically valid hypothesis tests and comparisons of interest. The information we want to glean from the simulation data must be considered in the design of the experiment.

Conclusion 1: Good variance reduction results are obtained through the use of common random numbers applied to a classical two-level fractional factorial design based on blocking within the fractional replication. The very large size of the TSAR and TSARINA models and the scope of the problem make the variance reduction significant. Additional replications of a completely randomized design which would give the same precision as our blocking design would cost about 480 additional minutes (almost 8 hours) of computer time on the NP-1 Gould supercomputer. This breaks down to 402 minutes for additional replications of the attack case and 78 minutes for the no-attack case. Further, no extraordinary time or effort is necessary to apply the variance reduction technique of common random numbers to the TSAR/TSARINA models. Rather the blocking scheme is easy to use and fits naturally into the design of the experiment. In fact, the design is a standard fractional factorial available in factorial design books. Thus this "real-life" application is a good example of where variance reduction techniques yield good results and reveal that such techniques may be very useful even in large-scale, very complex simulation experiments.

Conclusion 2: Our results appear to confirm that the variance of daily sorties flown is not homogeneous between the attack and no-attack cases, thus justifying the innovation of running the experiment as two sub-experiments. This structure allows comparison of like design points for the two cases where we test the hypothesis of no difference in the daily mean response and estimate confidence intervals for the difference. The use of common random numbers induces correlation between the two cases and results in a smaller variance for the difference in mean responses for a given design point.

Research Objective 2: Estimating Metamodels

This objective involves the estimation of simpler metamodels from the simulation results so that sorties can be predicted based on resource inputs. A metamodel is estimated for each day and includes significant main effects and two-way interactions.

Conclusion 1: Two-way interactions between the main effects are extremely important. While other research has shown the importance of the main effects, this research shows that two-way interactions are just as important in explaining sortie performance and should not be excluded in analyses.

Conclusion 2: As evident from the results, the logistics infrastructure and the generation of sorties involves many complex and interdependent relationships. One particular observation is the apparent cost of flying early in the 30-day time period at the expense of later sorties. Many incidents occur where the high level of a resource or interaction term appears to allow the flying of additional sorties in the early period; however that same high level seems to result in fewer sorties flown (i.e., negative beta coefficients in the predictor equation) in later daily models. Thus we conclude that one resource level may be sufficient for immediate capability, but a different level may be necessary and more beneficial for sustained capability. Both the readiness (i.e., immediate capability) and the sustainability of the logistics infrastructure are important. However, readiness does not appear to necessarily lead to sustainability and vice versa. This could be very important with a fixed budget and/or planning horizon.

Conclusion 3: The air base logistics infrastructure as modeled here still contains much unexplained variance as evidenced by the R^2 results. The average R^2 for the attack case is 0.6366 while the no-attack case averages 0.6789. Either the problem has a high degree of inherent variability, some other important factors are omitted, or some higher-order interactions are not negligible.

Research Objective 3: Impact of Attacks

The experimental design is structured so that the impact of attacks on the sortie generation effort can be estimated.

Here we want to estimate the difference that attacks make on the level of flying attained and determine whether different resources are more important than others in the presence of air base attacks.

Conclusion 1: When attacks on the air base are included, different daily metamodels result than for the no-attack case. The attacks cause apparent losses of resources which, in turn, degrade sortie generation. This results in those resources becoming significant factors in the attack case whereas they may not be significant in the no-attack case. Conversely, since the attacks slow flying and hence the use of consumable resources (e.g., missiles and fuel), these resources become less important than in the no-attack case where higher sortie rates are possible and lead to higher resource consumption.

Conclusion 2: The attacks appear to significantly degrade sortie results during the attack period regardless of the resource posture (except when Recovery resources are high). After the attacks on Days 1-5, the air base recovers to some maximum level of sortie production per day which then decreases almost linearly over time. For the situation where all resource factors are high, this recovery capability is about 190 sorties per day compared to about 150 sorties per day when all factors are low (see Figure 6.1. Note: Figure 5.9 is repeated here as Figure 6.1). The resource posture seems to have more bearing on that maximum recovery level of

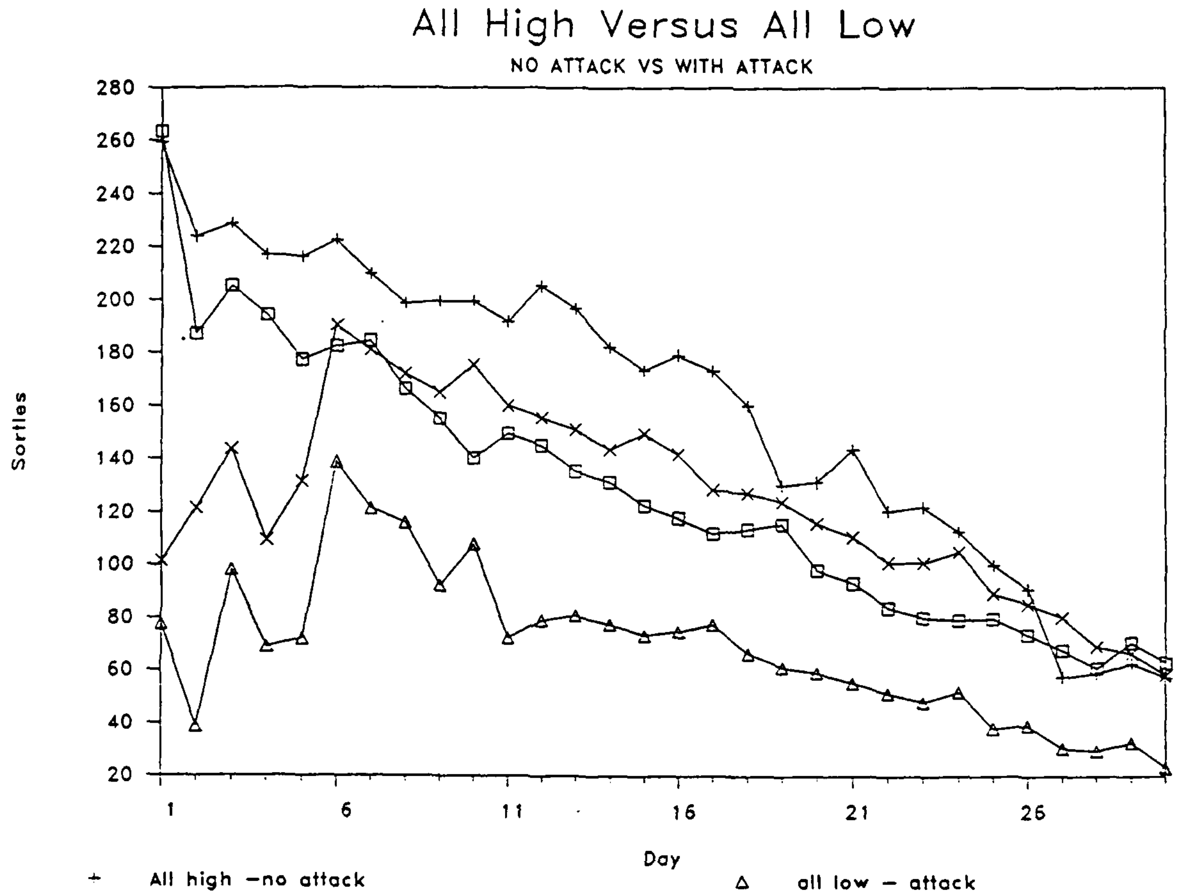


Figure 6.1

Comparison of Effects of Attacks and Resource Levels sorties per day than the attacks themselves. As seen in Figure 6.1, sortie generation appears to degrade by 5-7 sorties per day once the air base has recovered from the attacks. If the resources in place on Day 1 can be adequately protected, the long-term effect of the attacks may be minimized although we lose a significant number of sorties during the attack period due to runway closures.

Research Objective 4: Key Resources

The rank-order results for the separate cases, attack and no-attack, are next synthesized to subjectively rank the factors with regard to potential sortie contributions over the thirty day period when the likelihood of attack is unknown. If a factor is found to be relatively unimportant, this is based on a comparison of the high and low levels, not on the absence of the factor altogether. Thus some basic capability is assumed to be important for all the factors. The factors are discussed below in rank order, most important to least important.

Filler aircraft are the surest way to increase sortie production with or without air base attacks. This is logical since extra aircraft keep the pool of aircraft potentially available to fly at a high level. Whether or not aircraft will be available as replacements during a war is another question due to the expense of aircraft (and limited budgets) plus the lengthy procurement pipeline. Potential sources of filler aircraft include US Air Force Reserve and Air National Guard assets which usually mobilize after active-duty units.

Spare parts are ranked second overall due to the consistent contributions to sortie production in both cases. Spares, like aircraft, are expensive and the pipelines for procurement and repair are long. A possible action to consider is the adequate protection of existing resources from attacks since spares are very vulnerable and sensitive to attacks on the air base.

Missiles and fuel are jointly ranked third due to their importance and similarity in meeting high sustained sortie rates. Both are consumables which must be available to meet the high demands for sorties. While both did not appear to be susceptible to air base attacks in the modeling done in this research, they are resources which must be resupplied. Deliveries are potentially very vulnerable to interception, sabotage, and destruction. Sufficient protection and "safe" modes of transportation ought to be considered for these resources.

Support equipment proved to be a very large contributor in the presence of attacks, thus suggesting that important assets are lost in the attacks. Since the low resource level seems sufficient to support flying in the no-attack case, better protection in case of attack might be adequate rather than more equipment. The potential gains are high if these equipment can be adequately protected.

AIS test set (i.e., having an additional set) makes little contribution in the no-attack case, but consistently provides added sorties in the attack case after Day 10. Thus it seems that the impact of the attack on either spare parts or the AIS itself increases the value of having the second set of AIS. Due to the expense and difficulties in maintaining the AIS, additional sets may not be realistic. Alternatively, we ought to ensure adequate protection of available resources.

Recovery resources and maintenance personnel reflect resources that provide significant additional sorties in the early days of the war. Since the war may be won or lost in the first days of hostilities, these sorties may be extremely important and outweigh the value of later sorties. As with most of the resources, procurement can be expensive and training can be long.

ABDR capability contributes the least of all the factors when both cases are considered. This may simply mean that the low level is sufficient and the high level of capability is not necessary.

Limitations

Several limitations are evident in this research. First, the value of sorties is assumed to be equal and time independent. However, early sorties may actually be more valuable and influential in determining the outcome of the war. Also different types of flying missions may have different values. We do not address any difference in sortie values.

A second limitation is that the cost of resources is not considered. Increasing the level of one resource may lead to more sorties, but may be prohibitively expensive or less cost-effective than increasing another resource.

Although this research broadens the inference space of previous research approaches, there are still limitations to the conclusions we can draw. Since the independent variables are qualitative, we can predict only at the low and high levels, thus missing any resource or capability positions in between. Also, although we have included random versions of an optimized attack, there are still countless other attacks which are not considered. This further limits the inference space when the metamodels are used to predict performance.

A final limitation is the modeling of thirty separate metamodels, one for each day. A measure which spans the time period of interest might prove beneficial in comparing various resource postures. These limitations provide several areas for future research.

Future Research

Several areas for continued work beyond the limitations mentioned above are possible. Topical areas are variance reduction, widening of the inference space, and performance measures.

Variance Reduction

Only one variance reduction technique, i.e., common random numbers, is used in this research. Although we obtained good results, there is ample room for further improvements. Another technique, the use of control variables, may improve the results found here. A control variable is a random variable that is correlated with the response variable Y and we know its expected value. Thus a random variable C is a control variable of Y if it is correlated with Y and we know μ_C. Lavenberg and Welch (1981) provide the following development of how the control variable C is used to construct an unbiased estimator for μ which has a smaller variance than the unbiased estimator Y where $E(Y) = \mu$. For any constant b,

$$Y(b) = Y - b(C - \mu_C)$$

is also an unbiased estimator of μ. Now

$$\mathrm{Var}[Y(b)] = \mathrm{Var}(Y) - 2b\,\mathrm{Cov}(Y,C) + b^2\mathrm{Var}(C).$$

If

$$2b\,\mathrm{Cov}(Y,C) > b^2\mathrm{Var}(C)$$

then Y(b) has a smaller variance than Y. The value of b which minimizes Var[Y(b)] is

$$B = Cov(Y,C) / Var(C)$$

and the resulting minimum variance is

$$Var[Y(B)] = (1 - \rho^2_{YC})\ Var(Y)$$

where ρ^2_{YC} is the correlation coefficient between Y and C. Thus the greater the correlation between C and Y, the greater the variance reduction.

Lavenberg and Welch (1981) also identify the two key problems in applying control variables: a) finding control variables which are highly correlated with the estimators of interest, and b) estimating the optimum coefficient vector B which is unknown. Effective control variates may possibly be isolated in TSAR and/or TSARINA; additional experimentation with the models is required to find candidates. Some possibilities include aircraft break rates and attack attributes such as number of attackers, number of bombs dropped, etc. Break rates reflect how well the aircraft are operating and seem logically related to the number of sorties flown, i.e., as the break rate decreases, we expect to fly more sorties. We also ought to be able to calculate the expected break rate from the probabilities of failure for the 81 different systems/subsystems modeled by TSAR. Concerning the attacks on the air base, we would expect more damage and hence less flying if the number of attackers or the number of bombs dropped increases. Both of these factors are inputs to TSARINA and under the direct control of the experimenter.

Also the structure of the model allows easy computation of the expected value of both. Future experimentation is necessary to understand how these control variable candidates are treated within the simulation and to discover additional ones.

Further improvement in the variance reduction results might be realized with a modification to TSAR that isolates the random number streams used in the model. Streams could possibly be isolated by type of activity and this ought to allow more commonality in the use of random numbers between design points. For example, random number stream one, R_1 generated by random seed I_1, could be used to check whether or not an aircraft is attrited, R_2 (generated by random seed I_2) could be used to check whether or not there is battle damage, R_3 (generated by random seed I_3) could be used to check whether or not system x failed, etc. Each R_i could be initialized with a random seed I_i and thus we would have a seed vector

$$I_0 = [I_0(1), I_0(2), \ldots, I_0(i)]$$

which represents a common random number sequence to be used by a set or block of design points in the experimental design. Due to the complexity of the TSAR simulation, complete congruency of random number streams is difficult at best; however this suggested modification should allow a much "cleaner" application of the correlation induction technique of common random numbers which ought to lead to better variance reduction results.

Widening the Inference Space

The inference space can be expanded by allowing more levels within the resource structure of the experimental design and by diversifying the attack scenario. Some suggested approaches are discussed below.

The experimental design in this research is a two-level fractional factorial which attempts to bound the problem between the most likely high and low resource positions for each resource variable. While this may bound the inference space, it doesn't help the decision-maker using the estimated metamodels when the actual resource levels are somewhere in the middle; thus he/she must select either the high or the low as the closer or more representative. As a result, we potentially lose some precision in the true estimated capability of the logistics infrastructure. Further, previous experience with the model and the logistics environment indicate that there may be a threshold or "knee" in the curve as one moves from the low level to the high for many of the resources. With this in mind, further research with a three level design would be valuable.

In a three level experiment, we would add a middle or medium level to the high and low levels used in the two level design. Determining that middle level requires experimentation with TSAR to determine the appropriate value for each factor or resource. Connor and Zelen (1959) provide examples of fractional factorial designs for three level experiments. Their Plan 243.10.27 on page 37 is a 1/243 replication of 10 factors in 9 blocks of 27 observations each for a total of 243 observations per case (attack and no-attack) or a total of 586 simulation runs of 30 days each. All two-factor interactions except two are measurable with this design. Although this three level experimental design more than doubles the amount of simulation required by our two level design, the increased precision in predictions of the metamodels and the insights gained by decision makers may be well worth the expense.

Another research area concerning the expansion of the inference space deals with the hostile environment, specifically the attacks on the air base as modeled by TSARINA. Several issues require more research. One area concerns the variability of the attack results generated by TSARINA. Folkeson (1988) indicates that great variability in results occurs when the TSARINA random number seeds change. He claims that variance does not stabilize until about 1000 trials have been run. For research such as this thesis, 1000 trials is prohibitive; therefore more research is necessary to understand the attack results of TSARINA as influenced by the choice of random seed. Then, given this understanding, we need to know how to better incorporate these attack results in research concerning the sensitivity of sortie performance to the randomness of the attacks. For example, in this thesis, we used eight blocks where each block (in the attack case) represented a random version of the same attack. Would 16 blocks have been more appropriate given the randomness due to TSARINA, or would less have been sufficient? To answer these questions more research and experimentation with TSARINA is needed.

Another issue needing research is the effect of different types of attack on the air base. It would be useful to a decision maker at an air base to have some insights on how different types of attacks affect flying performance. Here the difference needs to be in terms of numbers of attackers, aim points, munitions used, etc. rather than just randomness of an attack where these factors are fixed. A possible approach might be where the blocks are different types of attacks rather than random versions of the same attack. This would broaden the inference space and provide a more general picture of the capability of the logistics infrastructure within an uncertain hostile environment.

Performance Measures

Research potential is great in the area of measures of performance over time. Possible approaches are discussed below for multivariate responses and time series analysis.

One of the above conclusions (Research Objective 2, Conclusion 2) is that resource postures that provide a high level of sorties in the early days do not necessarily lead to a high level of sorties later in the time period. Similarly, a posture that leads to a high level of flying in the later days may not provide or support very many sorties in the early days. Thus we have a potential conflict between immediate capability or readiness and sustained capability. Each of these two capability objectives may require a different set of resources and thus tradeoffs are necessary. This leads to a reconsideration of a measure of performance that is time dependent.

One approach might be to use a utility function which assigns weights to the daily sorties flown and then sum the weighted values over time to derive a single response. Thus for our thirty daily responses, we can develop a single objective function

$$Y = w_1 y_1 + w_2 y_2 + \ldots + w_{30} y_{30}$$

where y_i is the number of sorties flown on Day i and w_i is the appropriately chosen weight for the sorties flown on Day i. The problem with this approach is determining the weights which is highly subjective and highly dependent on the environmental scenario.

A second approach is to use multiple responses where the response $Y^{(k)}$ for a design point k is the vector of daily sorties flown

$$\underset{\sim}{Y}^{(k)} = [Y_1\ Y_2\ \ldots\ Y_{30}]$$

and we use multivariate multiple linear regression methods to estimate a metamodel. An alternative approach is to divide the responses into time periods of interest such as the first five days where immediate capability is important and then the days after that where sustained capability is more of a concern. For example, given that y_i is the number of sorties flown on Day i, we might let

$$Y_1^{(k)} = \sum_{i=1}^{5} y_i$$

$$Y_2^{(k)} = \sum_{i=6}^{30} y_i$$

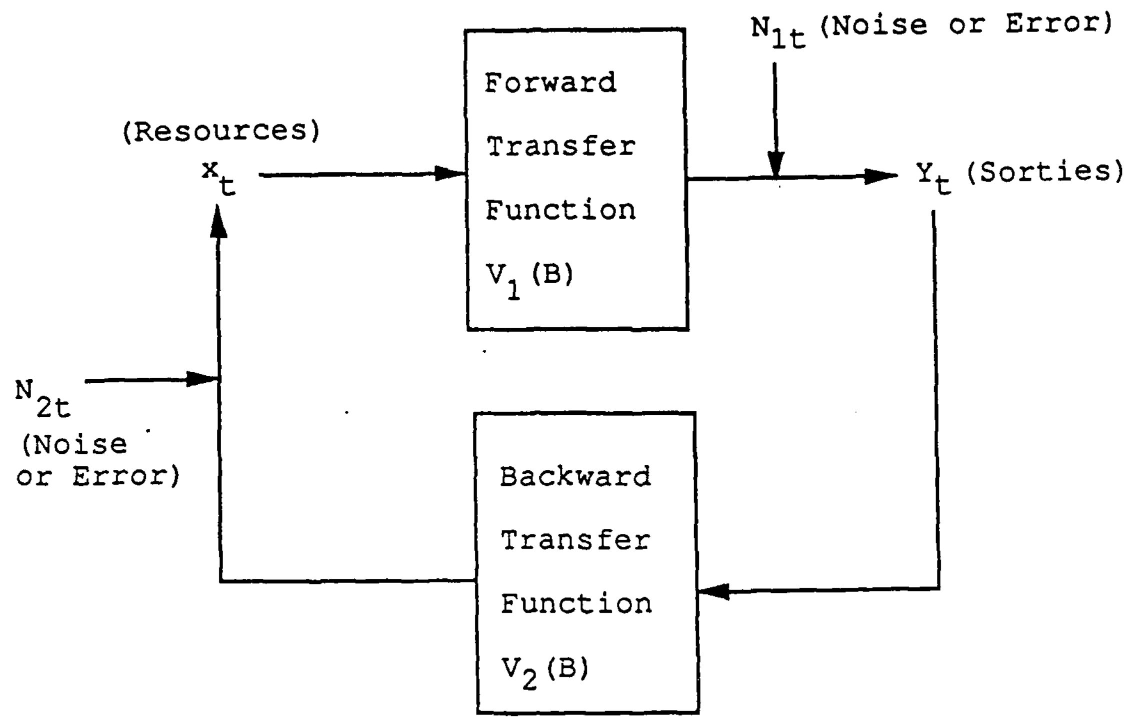
and the response of interest is

$$\underset{\sim}{Y}^{(k)} = [Y_1^{(k)}\ Y_2^{(k)}]$$

and we perform our multivariate estimation of the metamodel.

Useful approaches to this research problem may also be found in the field of time series analysis. Jenkins (1979) describes five classes of time series models which, with future research, could be applied to the sortie generation formulation described here. Based on our conclusions, two of the classes of models are particularly relevant. First is the multivariate stochastic model which assumes feedback between output and inputs. As our results indicate, resource levels help determine the number of sorties flown, but sorties flown also affect resource levels. Modeling the feedback between sorties and resources may help explain why high resource levels can lead to high sorties flown early in the time period of interest, but also result in fewer sorties in later days. Figure 6.2 is an adaptation of a figure in Jenkins and Alavi (1981) showing the feedback relationship between two variables. The idea is that the variables are treated on an equal or reciprocal basis to be able to describe the mutual dependence between them.

A second class of time series models which future research should explore is intervention models. Interventions are abnormal events or effects which are not easy to quantify; dummy variables are often used to represent such behavior either as pulse or step variables (Jenkins 1979). In our problem, attacks on the air base could be modeled as interventions or interruptions in the time series representing sorties flown. Box and Tiao (1975) describe responses to step and pulse inputs. Figure 6.3 presents a possible response based on the results of this research where attacks seem to cause an initial degradation in sorties flown from which the air base recovers to a level dictated by the resource posture of the logistics infrastructure. Lewis-Beck (1986) used a similar idea with interrupted time series analysis. He presents a least squares procedure which looks for intervention-induced changes in the mean and/or slope of

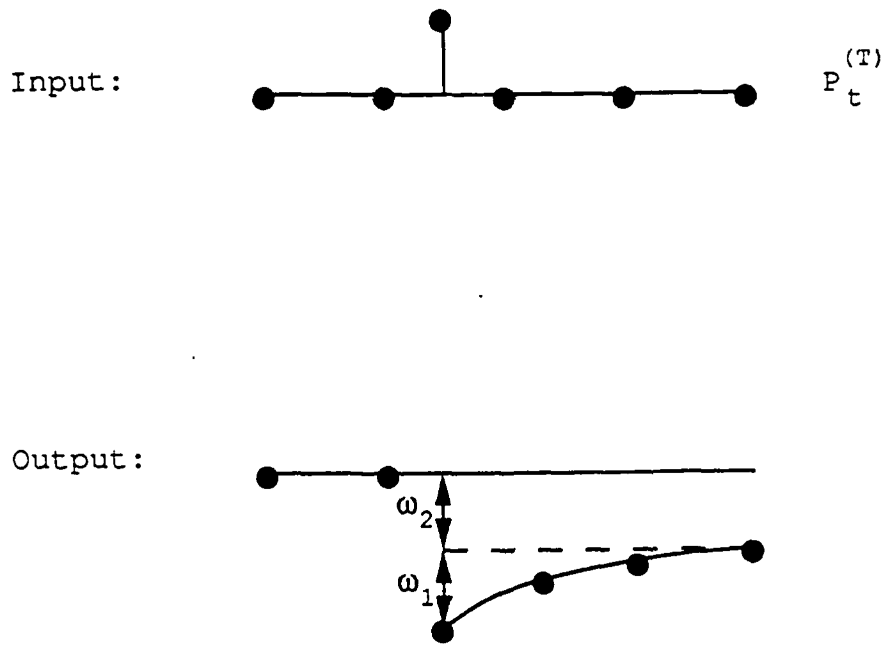


$$Y_t = V_1(B)X_t + N_{1t}$$

$$X_t = V_2(B)Y_t + N_{2t}$$

Figure 6.2

Multivariate Stochastic Model



$$\text{Initial Response} = \omega_1 + \omega_2$$

$$\text{Final Effect} = \omega_2$$

Figure 6.3

Response to an Attack as an Intervention a time series. These approaches have much potential for the modeling of air base attacks.

Lastly, response surface methodology or some type of optimization-through-simulation could be applied to find the optimal combination of resources to maximize sortie generation. Here, the problem would be approached as a planning or resourcing problem to outfit an air base to maximize performance with cost constraints. Research in this area is an almost entirely new approach to the air base problem described here rather than a straight-forward extension of our research. However, many of the same issues will have to be addressed, such as experimental design and variance reduction, for a successful application of optimization theory.

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APPENDICES

Appendix A: Equivalency of Model Forms

Let us consider a simple model with two factors at two levels each and an interaction term. Two coding schemes for the factor levels can be used. In Model 1 we use (0,1) to respectively denote the low and high level of each factor. The form of the model is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_{12} X_1 X_2$$

and the various combinations of factor levels gives the following equations for the dependent variable:

	$X_1 = 0$	$X_1 = 1$
$X_2 = 0$	β_0	$\beta_0 + \beta_1$
$X_2 = 1$	$\beta_0 + \beta_2$	$\beta_0 + \beta_1 + \beta_2 + \beta_{12}$

A second coding scheme uses (-1,1) to respectively denote the low and high level of each factor. The form of Model 2 is:

$$Y = \mu + \alpha + \beta + \gamma$$

and the various combinations of factor levels gives the following equations for the dependent variable:

	$X_1 = -1$	$X_1 = +1$
$X_2 = -1$	$\mu-\alpha-\beta+\gamma$	$\mu+\alpha-\beta-\gamma$
$X_2 = +1$	$\mu-\alpha+\beta-\gamma$	$\mu+\alpha+\beta+\gamma$

Based on equivalency, we have the following simultaneous equations which can be solved for values of the parameters of Model 2:

(1) $\beta_0 = \mu - \alpha - \beta + \gamma$

(2) $\beta_0 + \beta_1 = \mu + \alpha - \beta - \gamma$

(3) $\beta_0 + \beta_2 = \mu - \alpha + \beta - \gamma$

(4) $\beta_0 + \beta_1 + \beta_2 + \beta_{12} = \mu + \alpha + \beta + \gamma$

By adding all four equations we obtain:

(5) $\mu = \beta_0 + \frac{\beta_1}{2} + \frac{\beta_2}{2} + \frac{\beta_{12}}{4}$

By adding (1) and (3) we solve for α:

$$\beta_0 + \frac{\beta_2}{2} = \mu - \alpha = (\beta_0 + \frac{\beta_1}{2} + \frac{\beta_2}{2} + \frac{\beta_{12}}{4}) - \alpha$$

(6) $\alpha = \frac{\beta_1}{2} + \frac{\beta_{12}}{4}$

By adding (1) and (2) we solve for β:

$$\beta_0 + \frac{\beta_1}{2} = \mu - \beta = (\beta_0 + \frac{\beta_1}{2} + \frac{\beta_2}{2} + \frac{\beta_{12}}{4}) - \beta$$

(7) $\beta = \frac{\beta_2}{2} + \frac{\beta_{12}}{4}$

Now we can solve (1) for γ by substituting (5), (6), and (7) for values in (1):

(1) $\beta_0 = \mu - \alpha - \beta + \gamma$

$$\beta_0 = (\beta_0 + \frac{\beta_1}{2} + \frac{\beta_2}{2} + \frac{\beta_{12}}{4}) - (\frac{\beta_1}{2} + \frac{\beta_{12}}{4}) - (\frac{\beta_2}{2} + \frac{\beta_{12}}{4}) + \gamma$$

(8) $\gamma = \frac{\beta_{12}}{4}$

From this simple example we can see that we can express the equivalency between the two models and coding schemes. It is also apparent that the computations can be very extensive to express this equivalency for ten factors including all two-way interactions.

Appendix B: Regression Results for No-Attack Case

DAY 1 -- REDUCED MODEL NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	18	3018.24077	167.68004	7.847	0.0001
ERROR	109	2329.06392	21.36755890		
C TOTAL	127	5347.30469			

ROOT MSE	4.622506	R-SQUARE	0.5644
DEP MEAN	264.2109	ADJ R-SQ	0.4925
C.V.	1.749551		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	263.66690	1.07629975	244.975	0.0001
B1	1	-1.21093750	1.08098954	-1.120	0.2651
B2	1	-0.33593750	1.08098954	-0.311	0.7566
B3	1	-0.71093750	1.08098954	-0.658	0.5121
B4	1	-6.14843750	1.08098954	-5.688	0.0001
B5	1	8.28906250	1.08098954	7.668	0.0001
B6	1	-1.46093750	1.08098954	-1.351	0.1793
B7	1	1.66406250	1.08098954	1.539	0.1266
A	1	-2.99573864	1.35695733	-2.208	0.0294
F	1	4.23721591	1.48851274	2.847	0.0053
G	1	5.23437500	1.41534754	3.698	0.0003
AC	1	6.80397727	1.42247780	4.783	0.0001
AG	1	-3.59375000	1.63430256	-2.199	0.0300
BD	1	2.24431818	1.13798224	1.972	0.0511
BF	1	-2.71590909	1.28810843	-2.108	0.0373
CD	1	-2.48579545	1.19013031	-2.089	0.0391
CF	1	-2.44602273	1.42247780	-1.720	0.0884
CJ	1	-3.36363636	1.08332681	-3.105	0.0024
FG	1	-5.21875000	1.63430256	-3.193	0.0018

DAY 2 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	18	26657.62760	1480.97931	8.529	0.0001
ERROR	109	18927.11458	173.64325		
C TOTAL	127	45584.74219			

ROOT MSE	13.17738	R-SQUARE	0.5848
DEP MEAN	212.8672	ADJ R-SQ	0.5162
C.V.	6.190422		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	187.15885	3.74407200	49.988	0.0001
B1	1	-1.36718750	3.08157677	-0.444	0.6582
B2	1	5.38281250	3.08157677	1.747	0.0835
B3	1	-0.30468750	3.08157677	-0.099	0.9214
B4	1	-2.86718750	3.08157677	-0.930	0.3542
B5	1	-4.17968750	3.08157677	-1.356	0.1778
B6	1	-1.61718750	3.08157677	-0.525	0.6008
B7	1	4.00781250	3.08157677	1.301	0.1961
B	1	7.35937500	4.03473109	1.824	0.0709
D	1	10.98437500	4.03473109	2.722	0.0075
E	1	20.82812500	2.85298571	7.300	0.0001
G	1	7.96875000	3.29434414	2.419	0.0172
J	1	19.03125000	4.65890616	4.085	0.0001
AK	1	7.30208333	2.68982073	2.715	0.0077
BD	1	-8.90625000	4.65890616	-1.912	0.0585
BJ	1	-9.09375000	4.65890616	-1.952	0.0535
DJ	1	-14.09375000	4.65890616	-3.025	0.0031
EH	1	7.12500000	3.29434414	2.163	0.0327
GJ	1	-11.84375000	4.65890616	-2.542	0.0124

DEP VARIABLE: SORTIES

DAY 3 -- REDUCED MODEL -- NO ATTACK

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	19	20893.91916	1099.67996	8.712	0.0001
ERROR	108	13633.07303	126.23216		
C TOTAL	127	34526.99219			

ROOT MSE	11.23531	R-SQUARE	0.6051
DEP MEAN	210.0078	ADJ R-SQ	0.5357
C.V.	5.349948		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	205.05336	2.49076223	82.326	0.0001
B1	1	2.80468750	2.62741720	1.067	0.2881
B2	1	6.55468750	2.62741720	2.495	0.0141
B3	1	5.17968750	2.62741720	1.971	0.0512
B4	1	3.24218750	2.62741720	1.234	0.2199
B5	1	-5.44531250	2.62741720	-2.072	0.0406
B6	1	-8.32031250	2.62741720	-3.167	0.0020
B7	1	-4.13281250	2.62741720	-1.573	0.1187
A	1	-8.40625000	2.80882713	-2.993	0.0034
E	1	19.17187500	1.98614071	9.653	0.0001
K	1	-14.53690160	3.77363028	-3.852	0.0002
AK	1	9.15625000	3.97228142	2.305	0.0231
BF	1	-6.10217199	2.93545763	-2.079	0.0400
BH	1	5.35505319	3.10227061	1.726	0.0872
BJ	1	-6.89383865	2.93545763	-2.348	0.0207
BK	1	9.00797872	3.41151372	2.640	0.0095
DF	1	5.93107270	2.85819518	2.075	0.0404
DH	1	-8.23670213	2.99209547	-2.753	0.0069
DJ	1	7.88940603	2.85819518	2.760	0.0068
HK	1	11.25332447	3.32849608	3.381	0.0010

DAY 4 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	16	15892.85286	993.30330	6.693	0.0001
ERROR	111	16473.57682	148.41060		
C TOTAL	127	32366.42969			

ROOT MSE	12.18239	R-SQUARE	0.4910
DEP MEAN	205.2266	ADJ R-SQ	0.4177
C.V.	5.936068		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	194.08203	2.10821923	92.060	0.0001
B1	1	0.14843750	2.84889536	0.052	0.9585
B2	1	-3.35156250	2.84889536	-1.176	0.2419
B3	1	0.08593750	2.84889536	0.030	0.9760
B4	1	1.77343750	2.84889536	0.623	0.5349
B5	1	-8.16406250	2.84889536	-2.866	0.0050
B6	1	-6.22656250	2.84889536	-2.186	0.0309
B7	1	7.96093750	2.84889536	2.794	0.0061
E	1	10.57942708	3.26011709	3.245	0.0016
J	1	11.37630208	3.59823277	3.162	0.0020
BH	1	6.48437500	3.04559725	2.129	0.0355
BJ	1	8.78906250	3.40508124	2.581	0.0112
CJ	1	-8.15625000	3.04559725	-2.678	0.0085
DF	1	4.78125000	2.48671974	1.923	0.0571
EH	1	-5.64843750	3.40508124	-1.659	0.1000
EK	1	7.77083333	3.51675279	2.210	0.0292
JK	1	-13.35416667	3.51675279	-3.797	0.0002

DAY 5 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	16	21010.65969	1167.25887	6.934	0.0001
ERROR	109	18350.08249	168.34938		
C TOTAL	127	39360.74219			

ROOT MSE	12.97495	R-SQUARE	0.5338
DEP MEAN	198.1328	ADJ R-SQ	0.4568
C.V.	6.546613		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	177.16356	2.77114479	63.932	0.0001	INTERCEPT
B1	1	-3.44531250	3.03423907	-1.135	0.2587	
B2	1	-3.38281250	3.03423907	-1.115	0.2674	
B3	1	4.05468750	3.03423907	1.336	0.1842	
B4	1	9.42968750	3.03423907	3.108	0.0024	
B5	1	-1.69531250	3.[illegible]423907	-0.559	0.5775	
B6	1	-0.44531250	3.03423907	-0.147	0.8838	
B7	1	2.42968750	3.03423907	0.801	0.4250	
B	1	18.50756048	4.08853802	4.527	0.0001	Filler Aircraft
E	1	11.52604167	2.96111413	3.892	0.0002	Personnel
H	1	14.88541667	3.74554603	3.974	0.0001	Spare Parts
AD	1	-5.40322581	2.85410893	-1.893	0.0610	Attrition & Recovery
AK	1	5.55342742	3.19009079	1.740	0.0846	Attrition & Fuel
BH	1	-12.09375000	4.58733829	-2.636	0.0096	Fillers & Spares
BJ	1	7.93750000	3.24373801	2.447	0.0160	Fillers & Missiles
BK	1	-7.89012097	3.77563122	-2.090	0.0390	FILLERS & FUEL
CK	1	6.47681452	2.970[illegible]5076	2.180	0.0314	ABDR & FUEL
EF	1	6.91666667	3.74554603	1.847	0.0675	PERSONNEL & AIS
FH	1	-7.45833333	3.74554603	-1.991	0.0490	AIS & Spares

DAY 6 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	27	22879.76936	847.39887	10.405	0.0001
ERROR	100	8144.23064	81.44230644		
C TOTAL	127	31024.00000			

ROOT MSE	9.024539	R-SQUARE	0.7375
DEP MEAN	188.5	ADJ R-SQ	0.6666
C.V.	4.787554		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	182.29317	2.26817342	80.370	0.0001
B1	1	-1.12500000	2.11042084	-0.533	0.5952
B2	1	0.43750000	2.11042084	0.207	0.8362
B3	1	5.50000000	2.11042084	2.606	0.0106
B4	1	0.06250000	2.11042084	0.030	0.9764
B5	1	0.50000000	2.11042084	0.237	0.8132
B6	1	0.93750000	2.11042084	0.444	0.6578
B7	1	-0.37500000	2.11042084	-0.178	0.8593
C	1	8.64463539	3.02307885	2.860	0.0052
F	1	-6.01883377	3.11633536	-1.931	0.0563
K	1	-17.78716314	3.36106536	-5.292	0.0001
AB	1	-5.50391807	2.61148787	-2.108	0.0376
AD	1	-6.92287253	2.37184315	-2.919	0.0043
AE	1	5.40515564	2.64040053	2.047	0.0433
AH	1	4.28665874	2.42914046	1.765	0.0807
AK	1	9.49248811	2.86120315	3.318	0.0013
BC	1	5.50359382	2.90584954	1.894	0.0611
BD	1	4.83823317	2.38986735	2.024	0.0456
BE	1	6.91626135	2.62912474	2.631	0.0099
BG	1	-4.84349330	2.39385430	-2.023	0.0457
BJ	1	16.33572921	2.45258193	6.661	0.0001
CF	1	-5.50000000	3.19065641	-1.724	0.0878
CJ	1	-10.16786461	2.56786559	-3.960	0.0001
EF	1	7.03766753	2.88189513	2.442	0.0164
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
EK	1	5.03766753	2.88189513	1.748	0.0835
FK	1	10.87500000	3.19065641	3.408	0.0009
HK	1	6.79417063	2.56228902	2.652	0.0093

DAY 7 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	18	20816.59783	1156.47765	6.080	0.0001
ERROR	109	20733.33205	190.21406		
C TOTAL	127	41549.92989			

ROOT MSE	13.79181	R-SQUARE	0.5010
DEP MEAN	185.5234	ADJ R-SQ	0.4186
C.V.	7.433999		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	184.34477	2.51965781	73.163	0.0001
B1	1	0.22656250	3.22526451	0.070	0.9441
B2	1	8.97656250	3.22526451	2.783	0.0063
B3	1	-4.96093750	3.22526451	-1.538	0.1269
B4	1	5.60156250	3.22526451	1.737	0.0853
B5	1	-1.77343750	3.22526451	-0.550	0.5835
B6	1	-10.83593750	3.22526451	-3.360	0.0011
B7	1	2.91406250	3.22526451	0.904	0.3682
G	1	-10.74815089	3.67030663	-2.928	0.0041
J	1	-9.69443417	3.80210295	-2.550	0.0122
AG	1	6.56250000	3.44795279	1.903	0.0596
BC	1	7.21042899	3.56826620	2.021	0.0458
BD	1	7.01941568	3.53857138	1.984	0.0498
BG	1	8.71505178	4.26842683	2.042	0.0436
BJ	1	7.09005178	4.26842683	1.661	0.0996
CE	1	-6.42455621	3.48851834	-1.842	0.0682
DK	1	-9.54252959	3.32328651	-2.871	0.0049
EJ	1	15.08006657	4.06585503	3.709	0.0003
EK	1	9.88942308	3.44795279	2.868	0.0050

DAY 8 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	19	51057.35100	2687.22900	6.133	0.0001
ERROR	108	47319.52400	438.14374		
C TOTAL	127	98376.87500			

ROOT MSE	20.93188	R-SQUARE	0.5190
DEP MEAN	171.4063	ADJ R-SQ	0.4344
C.V.	12.21186		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	166.24777	4.47760965	37.129	0.0001
B1	1	-1.28125000	4.89499600	-0.262	0.7940
B2	1	-0.96875000	4.89499600	-0.198	0.8435
B3	1	-2.96875000	4.89499600	-0.606	0.5455
B4	1	12.84375000	4.89499600	2.624	0.0100
B5	1	-3.90625000	4.89499600	-0.798	0.4266
B6	1	-6.40625000	4.89499600	-1.309	0.1934
B7	1	-0.46875000	4.89499600	-0.096	0.9239
A	1	-9.13337054	4.86995749	-1.875	0.0634
D	1	-10.07812500	4.53188568	-2.224	0.0282
H	1	19.61607143	5.76645301	3.402	0.0009
J	1	-12.12332589	5.95419844	-2.036	0.0442
AG	1	14.07924107	6.33229629	2.223	0.0283
BE	1	-18.00334821	5.68101935	-3.169	0.0020
BG	1	11.01227679	5.68101935	1.938	0.0552
BJ	1	31.49553571	6.25459646	5.036	0.0001
DF	1	11.59375000	5.23297084	2.216	0.0288
EH	1	-19.87388393	6.33229629	-3.138	0.0022
EJ	1	31.50111607	6.33229629	4.975	0.0001
GH	1	-17.73325893	6.33229629	-2.800	0.0060

DAY 9 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	173721.52	8686.07598	15.326	0.0001
ERROR	107	60641.98047	566.74748		
C TOTAL	127	234363.50			

ROOT MSE	23.80646	R-SQUARE	0.7412
DEP MEAN	151.0625	ADJ R-SQ	0.6929
C.V.	15.75934		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	155.03516	5.15424953	30.079	0.0001
B1	1	0.31250000	5.56722578	0.056	0.9553
B2	1	0.06250000	5.56722578	0.011	0.9911
B3	1	0.56250000	5.56722578	0.101	0.9197
B4	1	6.37500000	5.56722578	1.145	0.2547
B5	1	-10.31250000	5.56722578	-1.852	0.0667
B6	1	1.75000000	5.56722578	0.314	0.7539
B7	1	5.50000000	5.56722578	0.988	0.3254
B	1	-21.50000000	5.43305604	-3.957	0.0001
C	1	-9.44921875	5.36471300	-1.761	0.0810
E	1	-42.87890625	7.77895243	-5.512	0.0001
H	1	13.57031250	5.36471300	2.530	0.0129
AE	1	-16.07812500	6.65410753	-2.416	0.0174
AK	1	13.71875000	5.95161470	2.305	0.0231
BJ	1	50.68750000	6.87233270	7.376	0.0001
CF	1	15.89843750	6.65410753	2.389	0.0186
DE	1	-11.28125000	5.95161470	-1.895	0.0607
EG	1	20.74218750	6.65410753	3.117	0.0023
EJ	1	59.18750000	6.87233270	8.612	0.0001
FG	1	-13.04687500	5.95161470	-2.192	0.0305
HK	1	-15.20312500	6.65410753	-2.285	0.0243

DAY 10 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	45625.50437	2281.27522	18.155	0.0001
ERROR	107	13445.30032	125.65701		
C TOTAL	127	59070.80469			

ROOT MSE	11.20968	R-SQUARE	0.7724
DEP MEAN	168.0391	ADJ R-SQ	0.7298
C.V.	6.67088		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	140.12771	2.31446877	60.544	0.0001	INTERCEPT
B1	1	-1.03906250	2.62142478	-0.396	0.6926	
B2	1	-0.60156250	2.62142478	-0.229	0.8189	
B3	1	-3.72656250	2.62142478	-1.422	0.1581	
B4	1	4.39843750	2.62142478	1.678	0.0963	
B5	1	1.14843750	2.62142478	0.438	0.6622	
B6	1	-1.03906250	2.62142478	-0.396	0.6926	
B7	1	6.39843750	2.62142478	2.441	0.0163	
B	1	30.35482900	3.00060050	10.116	0.0001	Filler Aircraft
F	1	11.37385507	3.65535908	3.112	0.0024	AIS
H	1	10.67241691	2.63976041	4.043	0.0001	Spare Parts
AB	1	-8.65588673	3.17458390	-2.727	0.0075	ATTRITION & FILLERS
AG	1	7.99927746	2.98289769	2.682	0.0085	Attrition & Spt Equip
BJ	1	8.97748073	3.16981367	2.832	0.0055	Fillers & Missiles
EF	1	-9.08869220	3.44874408	-2.635	0.0097	PERSONNEL & AIS
EG	1	8.19147399	3.16025162	2.592	0.0109	Personnel & Spt Equip
EJ	1	15.23253854	2.96253637	5.142	0.0001	Personnel & Missiles
EK	1	-6.43412813	2.96253637	-2.172	0.0321	Personnel & Fuel
FG	1	-6.81358382	3.48800998	-1.953	0.0534	AIS & SPT EQUIP
FK	1	5.31081407	3.16981367	1.675	0.0968	AIS & Fuel
GH	1	-7.87608382	3.48800998	-2.258	0.0260	SPT EQUIP & SPARES

DAY 11 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	16	63058.70313	3941.04395	20.380	0.0001
ERROR	111	21465.01562	193.37852		
C TOTAL	127	84521.71875			

ROOT MSE	13.90608	R-SQUARE	0.7460
DEP MEAN	173.5469	ADJ R-SQ	0.7094
C.V.	8.012856		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	149.52344	3.13368839	47.715	0.0001
B1	1	4.20312500	3.25198213	1.292	0.1989
B2	1	1.32812500	3.25198213	0.408	0.6838
B3	1	-0.73437500	3.25198213	-0.226	0.8218
B4	1	-2.48437500	3.25198213	-0.764	0.4465
B5	1	2.20312500	3.25198213	0.677	0.4995
B6	1	0.01562500	3.25198213	0.005	0.9962
B7	1	1.01562500	3.25198213	0.312	0.7554
A	1	6.40625000	3.47651513	1.843	0.0680
B	1	44.25000000	3.47651513	12.728	0.0001
H	1	16.94531250	3.13368839	5.407	0.0001
K	1	-13.80468750	3.58350977	-3.852	0.0002
AB	1	-9.37500000	4.91653485	-1.907	0.0591
CJ	1	-6.96875000	3.47651513	-2.005	0.0474
CK	1	7.92187500	3.88686208	2.038	0.0439
EK	1	9.62500000	3.47651513	2.769	0.0066
HJ	1	-12.70312500	3.88686208	-3.268	0.0014

DAY 12 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	16	63441.88958	3965.11810	19.664	0.0001
ERROR	111	22381.98542	201.63951		
C TOTAL	127	85823.87500			

ROOT MSE	14.19998	R-SQUARE	0.7392
DEP MEAN	166.7813	ADJ R-SQ	0.7016
C.V.	8.514136		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	144.98646	2.55172016	56.819	0.0001
B1	1	0.46875000	3.32071688	0.141	0.8880
B2	1	4.59375000	3.32071688	1.383	0.1693
B3	1	2.09375000	3.32071688	0.631	0.5297
B4	1	-3.59375000	3.32071688	-1.082	0.2815
B5	1	-1.90625000	3.32071688	-0.574	0.5671
B6	1	-0.09375000	3.32071688	-0.028	0.9775
B7	1	4.40625000	3.32071688	1.327	0.1873
B	1	40.53125000	2.51022601	16.146	0.0001
G	1	-13.65000000	4.89333134	-2.790	0.0062
AF	1	7.54166667	2.89855933	2.602	0.0105
DG	1	-8.84166667	3.99538831	-2.213	0.0289
DH	1	11.43333333	3.66641976	3.118	0.0023
EG	1	10.25000000	3.54999567	2.887	0.0047
GH	1	12.02500000	4.20041152	2.863	0.0050
GJ	1	7.74166667	3.99538831	1.938	0.0552
HJ	1	-6.73333333	3.66641976	-1.836	0.0690

DEP VARIABLE: SORTIES

DAY 13 -- REDUCED MODEL -- NO ATTACK

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	61000.63906	3588.27289	23.408	0.0001
ERROR	110	16862.41561	153.29469		
C TOTAL	127	77863.05469			
ROOT MSE		12.38122	R-SQUARE	0.7834	
DEP MEAN		160.4141	ADJ R-SQ	0.7500	
C.V.		7.71829			

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	135.19833	2.08513220	64.839	0.0001
B1	1	1.14843750	2.89539345	0.397	0.6924
B2	1	1.46093750	2.89539345	0.505	0.6149
B3	1	-1.03906250	2.89539345	-0.359	0.7204
B4	1	-0.53906250	2.89539345	-0.186	0.8526
B5	1	1.89843750	2.89539345	0.656	0.5134
B6	1	-7.35156250	2.89539345	-2.539	0.0125
B7	1	7.71093750	2.89539345	2.663	0.0089
B	1	39.35937500	2.18871172	17.983	0.0001
AC	1	-8.95003094	2.93807968	-3.046	0.0029
AE	1	6.35210396	2.84513075	2.233	0.0276
CE	1	8.98746906	2.93807968	3.059	0.0028
CH	1	7.85426980	3.27885118	2.395	0.0183
DK	1	5.78094059	2.70848378	2.134	0.0350
FH	1	6.49786886	2.85345392	2.277	0.0247
GH	1	7.81002475	3.10040935	2.519	0.0132
GK	1	-6.62407178	2.92189179	-2.267	0.0253
HJ	1	-5.56451114	2.85345392	-1.950	0.0537

DAY 14 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	13	52408.75521	4031.28886	19.483	0.0001
ERROR	114	23586.11198	206.91326		
C TOTAL	127	75994.86719			

ROOT MSE	14.38448	R-SQUARE	0.6896
DEP MEAN	153.8203	ADJ R-SQ	0.6542
C.V.	9.351483		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	131.25000	2.32128547	56.542	0.0001
B1	1	7.61718750	3.36386223	2.264	0.0254
B2	1	-1.69531250	3.36386223	-0.504	0.6152
B3	1	-2.69531250	3.36386223	-0.801	0.4247
B4	1	-0.19531250	3.36386223	-0.058	0.9538
B5	1	0.17968750	3.36386223	0.053	0.9575
B6	1	-3.44531250	3.36386223	-1.024	0.3079
B7	1	-3.38281250	3.36386223	-1.006	0.3167
B	1	23.51041667	3.74296035	6.281	0.0001
H	1	15.68229167	3.28279339	4.777	0.0001
BD	1	11.29166667	4.15244168	2.719	0.0076
BE	1	13.46875000	3.59611998	3.745	0.0003
CJ	1	-4.96875000	2.93621967	-1.692	0.0933
DH	1	-7.89583333	4.15244168	-1.901	0.0598

DAY 15 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	53324.93594	3136.76094	19.014	0.0001
ERROR	110	18146.93125	164.97210		
C TOTAL	127	71471.86719			

ROOT MSE	12.84415	R-SQUARE	0.7461
DEP MEAN	144.3203	ADJ R-SQ	0.7069
C.V.	8.89975		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	122.40000	2.35415198	51.993	0.0001	INTERCEPT
B1	1	-5.44531250	3.00364975	-1.813	0.0726	
B2	1	-0.13281250	3.00364975	-0.044	0.9648	
B3	1	-4.57031250	3.00364975	-1.522	0.1310	
B4	1	2.05468750	3.00364975	0.684	0.4954	
B5	1	-0.19531250	3.00364975	-0.065	0.9483	
B6	1	0.80468750	3.00364975	0.268	0.7893	
B7	1	0.30468750	3.00364975	0.101	0.9194	
B	1	22.21718750	4.14024546	5.366	0.0001	Filler Aircraft
H	1	14.46093750	2.89436933	4.996	0.0001	Spare Parts
AB	1	7.07812500	3.59004812	1.972	0.0512	ATTRITION & FILLERS
AE	1	7.78125000	3.21103665	2.423	0.0170	Attrition & Personnel
BD	1	7.11875000	3.51751442	2.024	0.0454	Fillers & Recovery
BF	1	7.24375000	3.51751442	2.059	0.0418	Fillers & AIS
BJ	1	6.65625000	3.21103665	2.073	0.0405	Fillers & Missiles
CD	1	-5.17500000	2.87203849	-1.802	0.0743	ABDR & Recovery
EH	1	-8.57812500	3.59004812	-2.389	0.0186	Personnel & Spares
FK	1	-7.80000000	2.87203849	-2.716	0.0077	AIS & Fuel

DAY 16 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	22	71266.85691	3239.40259	18.185	0.0001
ERROR	105	18704.44778	178.13760		
C TOTAL	127	89971.30469			

ROOT MSE	13.34682	R-SQUARE	0.7921
DEP MEAN	140.2109	ADJ R-SQ	0.7485
C.V.	9.5191		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	117.71242	3.14036208	37.484	0.0001
B1	1	4.60156250	3.12120167	1.474	0.1434
B2	1	-5.52343750	3.12120167	-1.770	0.0797
B3	1	-2.58593750	3.12120167	-0.829	0.4093
B4	1	-0.96093750	3.12120167	-0.308	0.7588
B5	1	2.53906250	3.12120167	0.813	0.4178
B6	1	0.08593750	3.12120167	-0.028	0.9781
B7	1	0.72656250	3.12120167	0.233	0.8164
B	1	33.03623384	4.65996982	7.089	0.0001
C	1	-9.74730603	3.89419194	-2.503	0.0139
D	1	-5.71354167	3.04598094	-1.876	0.0635
G	1	11.08723958	3.57172925	3.104	0.0025
AB	1	-10.90301724	3.71766332	-2.933	0.0041
AJ	1	9.36853448	3.27867086	2.857	0.0052
BC	1	13.78125000	4.71881338	2.920	0.0043
BE	1	7.55711207	4.01553533	1.882	0.0626
BH	1	9.58593750	3.73054954	2.570	0.0116
CE	1	9.11961207	4.01553533	2.271	0.0252
DK	1	10.77083333	3.85289499	2.796	0.0062
EJ	1	-8.92133621	3.39374677	-2.629	0.0099
FG	1	-6.85156250	3.73054954	-1.837	0.0691
FH	1	6.01562500	3.33670494	1.803	0.0743
GK	1	-6.85416667	3.85289499	-1.779	0.0781

DAY 17 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	22	70517.88737	3205.35852	21.615	0.0001
ERROR	105	15570.66731	148.29207		
C TOTAL	127	86088.55469			

ROOT MSE	12.17752	R-SQUARE	0.8191
DEP MEAN	135.3359	ADJ R-SQ	0.7812
C.V.	8.997997		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	111.91548	2.42940848	46.067	0.0001
B1	1	8.10156250	2.84775746	2.845	0.0053
B2	1	2.16406250	2.84775746	0.760	0.4490
B3	1	2.22656250	2.84775746	0.782	0.4361
B4	1	-8.71093750	2.84775746	-3.059	0.0028
B5	1	-6.58593750	2.84775746	-2.313	0.0227
B6	1	0.35156250	2.84775746	0.123	0.9020
B7	1	0.78906250	2.84775746	0.277	0.7823
B	1	39.51345825	3.90293260	10.124	0.0001
D	1	-7.12655640	3.50890543	-2.031	0.0448
BF	1	8.37997437	3.78679917	2.213	0.0291
BG	1	6.29537964	3.61395016	1.742	0.0844
BJ	1	-9.85852051	3.88705357	-2.536	0.0127
CE	1	6.13467407	2.68245570	2.287	0.0242
CG	1	-6.74777222	3.02499437	-2.231	0.0278
DH	1	9.45538330	3.78161696	2.500	0.0140
DJ	1	8.07897949	3.88705357	2.078	0.0401
FH	1	9.80410767	3.42536880	2.862	0.0051
FJ	1	-6.32229614	3.40770759	-1.855	0.0664
FK	1	-5.67926025	3.15533399	-1.800	0.0747
GH	1	7.71951294	3.34335484	2.309	0.0229
HJ	1	-6.43436721	3.48950596	-1.844	0.0680
JK	1	8.08224487	3.19571251	2.529	0.0129

DEP VARIABLE: SORTIES

DAY 18 -- REDUCED MODEL -- NO ATTACK

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	25	57058.55963	2282.34239	17.904	0.0001
ERROR	102	13002.93256	127.47973		
C TOTAL	127	70061.49219			

ROOT MSE	11.29069	R-SQUARE	0.8144
DEP MEAN	126.2422	ADJ R-SQ	0.7689
C.V.	8.943676		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	113.65148	3.17423408	35.804	0.0001
B1	1	9.32031250	2.64036887	3.530	0.0006
B2	1	-2.92968750	2.64036887	-1.110	0.2698
B3	1	-2.49218750	2.64036887	-0.944	0.3475
B4	1	-3.11718750	2.64036887	-1.181	0.2405
B5	1	-2.17968750	2.64036887	-0.826	0.4110
B6	1	0.007812500	2.64036887	0.003	0.9976
B7	1	0.07031250	2.64036887	0.027	0.9788
B	1	9.75818452	4.58878196	2.127	0.0359
E	1	-9.75426136	3.85337403	-2.531	0.0129
F	1	14.81547619	4.13197026	3.586	0.0005
G	1	-11.01846[illegible]91	3.7582[illegible]430	-2.932	0.0042
AD	1	-5.77976190	2.75464684	-2.098	0.0384
AK	1	7.57440476	2.75464684	2.750	0.0071
BC	1	12.37500000	3.25934210	3.797	0.0002
BD	1	6.79613095	3.14078063	2.164	0.0328
BE	1	15.90625000	3.99186252	3.985	0.0001
BF	1	10.40625000	3.99186252	2.607	0.0105
BG	1	8.09375000	3.99186252	2.028	0.0452
CF	1	-12.43750000	3.25934210	-3.816	0.0002
EF	1	-8.78125000	3.99186252	-2.200	0.0301
EH	1	9.16477273	3.40427180	2.692	0.0083
FK	1	-7.53720238	3.14078063	-2.400	0.0182
GH	1	9.22727273	3.40427180	2.710	0.0079
GJ	1	[illegible]	[illegible]	[illegible]	[illegible]
HJ	1	-9.68181818	2.94818586	-3.284	0.0014

DAY 19 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	25	68468.07529	2738.72301	8.635	0.0001
ERROR	102	32352.39346	317.18033		
C TOTAL	127	100820.47			

ROOT MSE	17.80956	R-SQUARE	0.6791
DEP MEAN	116.1094	ADJ R-SQ	0.6005
C.V.	15.47186		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	115.50337	3.85023935	29.999	0.0001
B1	1	11.64062500	4.16482883	2.795	0.0062
B2	1	-[illegible].54687500	4.16482883	-1.332	0.1859
B3	1	3.20312500	4.16482883	0.769	0.4436
B4	1	-12.60937500	4.16482883	-3.028	0.0031
B5	1	8.39062500	4.16482883	2.015	0.0466
B6	1	-2.29687500	4.16482883	-0.551	0.5825
B7	1	-4.92187500	4.16482883	-1.182	0.2400
B	1	12.93625251	5.92944461	2.182	0.0314
K	1	-29.24845948	7.86215729	-3.720	0.0003
BC	1	15.00635466	5.41504532	2.771	0.0066
BJ	1	-12.62885968	5.68537606	-2.221	0.0285
BK	1	22.37500000	6.29662934	3.553	0.0006
CE	1	13.85593603	5.10090156	2.716	0.0078
CK	1	-14.18114534	5.41504532	-2.619	0.0102
DE	1	-11.14855995	5.01267672	-2.224	0.0283
DH	1	-9.48015740	4.90232968	-1.934	0.055
DK	1	13.18935867	5.37468173	2.454	0.0158
EG	1	-9.30732585	4.73367007	-1.966	0.0520
EH	1	-8.69493470	5.10610497	-[illegible].703	0.0916
EJ	1	-22.15427830	5.19120828	-4.268	0.0001
EK	1	14.09958138	5.74808687	2.453	0.0159
GJ	1	11.02673309	4.70835765	2.342	0.0211
HJ	1	-10.98587575	5.13979873	-2.137	0.0350
[illegible]	1	[illegible]	[illegible]	1.1[illegible]	[illegible]
JK	1	15.30864032	5.68537606	2.693	0.0083

DAY 20 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	22	46904.41658	2132.01894	11.207	0.0001
ERROR	105	19975.55217	190.24335		
C TOTAL	127	66879.96875			

ROOT MSE	13.79287	R-SQUARE	0.7013
DEP MEAN	109.0156	ADJ R-SQ	0.6387
C.V.	12.6522		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	98.03792342	3.11574342	31.465	0.0001	INTERCEPT
B1	1	1.42187500	3.22551289	0.441	0.6602	
B2	1	4.10937500	3.22551289	1.274	0.2055	
B3	1	1.54687500	3.22551289	0.480	0.6325	
B4	1	-7.64062500	3.22551289	-2.369	0.0197	
B5	1	7.17187500	3.22551289	2.223	0.0283	
B6	1	-1.20312500	3.22551289	-0.373	0.7099	
B7	1	-8.14062500	3.22551289	-2.524	0.0131	
B	1	8.98513439	5.04507221	1.781	0.0778	Filler Aircraft
C	1	-11.88386954	3.64269526	-3.262	0.0015	ABDR
D	1	13.69872975	4.52639864	3.026	0.0031	Recovery
AC	1	7.28125000	3.44821833	2.112	0.0371	Attrition & ABDR
BD	1	14.06250000	4.87651712	2.884	0.0048	Fillers & Recovery
BG	1	9.05357143	4.12140919	2.197	0.0302	Fillers & Spt Equip
BJ	1	-11.44587629	4.11290266	-2.783	0.0064	Fillers & Missiles
BK	1	18.60953608	4.05285707	4.592	0.0001	FILLERS & FUEL
CE	1	17.48646907	4.17208416	4.191	0.0001	ABDR & Personnel
DE	1	-13.51353093	4.17208416	-3.239	0.0016	Recovery & Personnel
DG	1	-14.69642857	4.12140919	-3.566	0.0005	Recovery & Spt Equip
EJ	1	-14.646907[illegible]2	3.73818951	-3.918	0.0002	Personnel & Missiles
FK	1	-8.13273196	3.17041281	-2.565	0.0117	AIS & Fuel
GH	1	7.40178571	3.19242983	2.319	0.0224	SPT EQUIP & SPARES
JK	1	10.85115979	3.67202163	2.955	0.0039	MISSILES & FUEL

DAY 21 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	28	65105.26714	2325.18811	14.895	0.0001
ERROR	99	15454.22505	156.10328		
C TOTAL	127	80559.49219			

ROOT MSE	12.49413	R-SQUARE	0.8082
DEP MEAN	110.2422	ADJ R-SQ	0.7539
C.V.	11.33335		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	93.07290263	2.96146764	31.428	0.0001
B1	1	1.50781250	2.92179710	0.516	0.6070
B2	1	4.57031250	2.92179710	1.564	0.1210
B3	1	-3.30468750	2.92179710	-1.131	0.2608
B4	1	-9.30468750	2.92179710	-3.185	0.0019
B5	1	-2.05468750	2.92179710	-0.703	0.4836
B6	1	3.44531250	2.92179710	1.179	0.2412
B7	1	2.00781250	2.92179710	0.687	0.4936
B	1	23.85345772	4.93502085	4.834	0.0001
E	1	-16.60057276	4.12169007	-4.028	0.0001
F	1	11.13883507	4.54672955	2.450	0.0160
AD	1	-7.05239218	3.24331453	-2.174	0.0321
AE	1	6.71369609	3.51940727	1.908	0.0593
BC	1	6.06250000	3.60674465	1.681	0.0959
BD	1	6.89016173	3.72981171	1.847	0.0677
BE	1	14.78125000	4.41734201	3.346	0.0012
BH	1	10.42494946	4.06062462	2.567	0.0117
BK	1	-11.14702662	3.77449220	-2.953	0.0039
CF	1	-9.81250000	3.60674465	-2.721	0.0077
DJ	1	7.08456873	3.49315666	2.028	0.0452
EH	1	8.73744946	4.06062462	2.152	0.0338
FG	1	-6.33452662	3.77449220	-1.678	0.0965
FH	1	11.54994946	4.06062462	2.844	0.0054
FJ	1	-13.08684299	3.96892127	-3.297	0.0014
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
GJ	1	6.98468039	3.49597865	1.998	0.0485
HJ	1	-8.50584353	3.64782782	-2.332	0.0217
HK	1	-8.19062716	3.54824391	-2.308	0.0231
JK	1	9.29738039	3.49597865	2.659	0.0091

DEP VARIABLE: SORTIES

DAY 22 -- REDUCED MODEL -- NO ATTACK

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	19	45465.79688	2392.93668	14.727	0.0001
ERROR	108	17548.82031	162.48908		
C TOTAL	127	63014.61719			

ROOT MSE	12.74712	R-SQUARE	0.7215
DEP MEAN	102.9453	ADJ R-SQ	0.6725
C.V.	12.38242		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	83.62500000	3.45963314	24.172	0.0001
B1	1	0.11718750	2.98095981	0.039	0.9687
B2	1	1.11718750	2.98095981	0.375	0.7086
B3	1	-1.13281250	2.98095981	-0.380	0.7047
B4	1	-1.82031250	2.98095981	-0.611	0.5427
B5	1	-2.32031250	2.98095981	-0.778	0.4380
B6	1	1.61718750	2.98095981	0.543	0.5886
B7	1	0.74218750	2.98095981	0.249	0.8039
B	1	29.53125000	4.03998112	7.310	0.0001
C	1	-6.43750000	3.18678009	-2.020	0.0459
E	1	-5.96875000	3.18678009	-1.873	0.0638
H	1	15.93750000	4.34284921	3.670	0.0004
J	1	7.34375000	3.18678009	2.304	0.0231
AK	1	5.03125000	2.95038506	1.705	0.0910
BC	1	7.84375000	4.50678762	1.740	0.0846
BG	1	10.21875000	3.18678009	3.207	0.0018
BK	1	-11.21875000	3.80893073	-2.945	0.0040
EH	1	7.53125000	4.50678762	1.671	0.0976
HJ	1	-15.15625000	4.50678762	-3.363	0.0011
HK	1	-7.78125000	3.80893073	-2.043	0.0435

DEP VARIABLE: SORTIES

DAY 23 -- REDUCED MODEL -- NO ATTACK

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	23	54884.54977	2386.28477	16.077	0.0001
ERROR	104	15436.56741	148.42853		
C TOTAL	127	70321.11719			

ROOT MSE	12.18312	R-SQUARE	0.7805
DEP MEAN	97.30469	ADJ R-SQ	0.7319
C.V.	12.52059		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	79.87412241	2.76917938	28.844	0.0001
B1	1	1.82031250	2.84906746	0.639	0.5243
B2	1	4.38281250	2.84906746	1.538	0.1270
B3	1	-6.17968750	2.84906746	-2.169	0.0324
B4	1	-2.30468750	2.84906746	-0.809	0.4204
B5	1	1.82031250	2.84906746	0.639	0.5243
B6	1	-0.05468750	2.84906746	-0.019	0.9847
B7	1	2.50781250	2.84906746	0.880	0.3808
B	1	25.16742979	3.54423515	7.101	0.0001
C	1	-11.78125000	3.51696523	-3.350	0.0011
F	1	14.35208807	3.69591214	3.884	0.0004
AC	1	10.87500000	3.51696523	3.092	0.0026
AF	1	-6.62500000	3.51696523	-1.884	0.0624
BC	1	7.96875000	4.30738512	1.850	0.0671
BH	1	13.72764042	3.62481419	3.787	0.0003
DE	1	-5.62625916	3.02899994	-1.857	0.0661
DH	1	7.00507479	3.07170324	2.281	0.0246
EG	1	7.17391838	3.22812742	2.222	0.0284
EK	1	-13.01896368	3.07170324	-4.238	0.0001
FG	1	-8.95364011	3.62637628	-2.469	0.0152
FJ	1	-6.84424603	3.74016045	-1.830	0.0701
GJ	1	8.98336386	3.35206623	2.680	0.0086
HJ	1	-7.08535582	3.30613369	-2.143	0.0344
JK	1	6.66548382	3.15898424	2.110	0.0373

DEP VARIABLE: SORTIES

DAY 24 -- REDUCED MODEL -- NO ATTACK

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	21	46386.12583	2208.86313	14.004	0.0001
ERROR	106	16719.37417	157.72995		
C TOTAL	127	63105.50000			

ROOT MSE	12.55906	R-SQUARE	0.7351
DEP MEAN	91.1875	ADJ R-SQ	0.6826
C.V.	13.77278		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	79.06523541	2.56891406	30.778	0.0001
B1	1	-2.00000000	2.93698083	-0.681	0.4974
B2	1	8.06250000	2.93698083	2.745	0.0071
B3	1	-7.56250000	2.93698083	-2.575	0.0114
B4	1	-6.00000000	2.93698083	-2.043	0.0435
B5	1	-4.25000000	2.93698083	-1.447	0.1508
B6	1	4.25000000	2.93698083	1.447	0.1508
B7	1	4.31250000	2.93698083	1.468	0.1450
B	1	19.63884284	3.97004125	4.947	0.0001
E	1	-12.52868037	3.81640105	-3.283	0.0014
F	1	7.76939655	2.91519822	2.665	0.0089
AB	1	9.24038462	3.69455096	2.501	0.0139
AG	1	5.68269231	2.88816334	1.968	0.0517
AH	1	-6.91346154	3.37264817	-2.050	0.0428
BD	1	7.63577586	3.49823766	2.183	0.0313
BH	1	6.72115385	3.79579028	1.771	0.0795
CD	1	-6.89655172	3.08515580	-2.235	0.0275
CJ	1	7.55387931	3.19343965	2.365	0.0198
EH	1	7.59615385	3.79579028	2.001	0.0479
EJ	1	8.58620690	3.77852875	2.272	0.0251
EK	1	-10.12500000	3.13976457	-3.225	0.0017
FJ	1	-10.35129310	3.77852875	-2.740	0.0072

DAY 25 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	35660.49546	2097.67620	11.212	0.0001
ERROR	110	20580.87172	187.09883		
C TOTAL	127	56241.36719			

ROOT MSE	13.67841	R-SQUARE	0.6341
DEP MEAN	84.57031	ADJ R-SQ	0.5775
C.V.	16.17401		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	79.43245968	3.16167601	25.124	0.0001	INTERCEPT
B1	1	-3.88281250	3.19874467	-1.214	0.2274	
B2	1	0.86718750	3.19874467	0.271	0.7868	
B3	1	-1.69531250	3.19874467	-0.530	0.5972	
B4	1	1.17968750	3.19874467	0.369	0.7130	
B5	1	-5.00781250	3.19874467	-1.566	0.1203	
B6	1	7.86718750	3.19874467	2.459	0.0155	
B7	1	0.61718750	3.19874467	0.193	0.8474	
A	1	-11.40877016	3.95658906	-2.884	0.0047	Attrition
B	1	24.09375000	3.82323115	6.302	0.0001	Filler Aircraft
E	1	-12.67187500	4.18813988	-3.026	0.0031	Personnel
AC	1	13.75504032	3.98033245	3.456	0.0008	Attrition & ABDR
AE	1	13.78125000	4.83604738	2.850	0.0052	Attrition & Personnel
BE	1	-8.59375000	4.83604738	-1.777	0.0783	Fillers & Personnel
BJ	1	12.25000000	3.41960189	3.582	0.0005	Fillers & Missiles
CH	1	-6.18447581	3.36399491	-1.838	0.0687	ABDR & Spares
CK	1	-10.95060484	3.13170882	-3.497	0.0007	ABDR & FUEL
DH	1	6.46774194	3.00884851	2.150	0.0338	Recovery & Spares

DAY 26 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	23	40843.46231	1775.80271	7.651	0.0001
ERROR	104	24138.50644	232.10102		
C TOTAL	127	64981.96875			

ROOT MSE	15.23486	R-SQUARE	0.6285
DEP MEAN	76.98438	ADJ R-SQ	0.5464
C.V.	19.78955		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	73.51295230	3.03866084	24.193	0.0001
B1	1	-1.54687500	3.56272715	-0.434	0.6651
B2	1	7.14062500	3.56272715	2.004	0.0476
B3	1	-5.60937500	3.56272715	-1.574	0.1184
B4	1	-1.98437500	3.56272715	-0.557	0.5787
B5	1	-3.60937500	3.56272715	-1.013	0.3134
B6	1	6.01562500	3.56272715	1.688	0.0943
B7	1	6.01562500	3.56272715	1.688	0.0943
B	1	36.49191338	5.35375522	6.816	0.0001
K	1	-12.93804825	4.70882450	-2.748	0.0071
AJ	1	-7.89843750	4.03975287	-1.955	0.0532
AK	1	8.38671875	4.31117325	1.945	0.0544
BC	1	-13.50130208	4.58300488	-2.946	0.0040
BE	1	-21.89638158	4.23580216	-5.169	0.0001
BH	1	-13.92598684	4.58213714	-3.039	0.0030
BJ	1	14.71484375	4.71304501	3.122	0.0023
CD	1	-8.96093750	4.03975287	-2.218	0.0287
CJ	1	9.02604167	4.11388295	2.194	0.0305
DJ	1	-7.11979167	4.11388295	-1.731	0.0865
DK	1	10.04036458	4.58300488	2.191	0.0307
EF	1	-9.26973684	3.70713147	-2.501	0.0140
FG	1	6.26809211	3.65528093	1.715	0.0894
GH	1	-7.09703947	3.85850477	-1.839	0.0687
HK	1	8.01151316	4.58213714	1.748	0.0833

DAY 27 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	18	41190.91007	2288.36389	5.760	0.0001
ERROR	109	43303.96493	397.28408		
C TOTAL	127	84494.87500			

ROOT MSE	19.93199	R-SQUARE	0.4875
DEP MEAN	64.90625	ADJ R-SQ	0.4029
C.V.	30.70889		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	67.53033724	3.70824940	18.211	0.0001
B1	1	-6.78125000	4.66116651	-1.455	0.1486
B2	1	1.40625000	4.66116651	0.302	0.7635
B3	1	0.59375000	4.66116651	0.127	0.8989
B4	1	2.96875000	4.66116651	0.637	0.5255
B5	1	-2.65625000	4.66116651	-0.570	0.5699
B6	1	4.96875000	4.66116651	1.066	0.2888
B7	1	4.84375000	4.66116651	1.039	0.3010
C	1	-12.18817258	4.68083019	-2.604	0.0105
D	1	11.87432744	4.68083019	2.537	0.0126
BE	1	-11.00470792	5.54325530	-1.985	0.0496
BH	1	-24.48472329	4.92714676	-4.969	0.0001
BJ	1	13.93601076	5.08348182	2.741	0.0072
BK	1	26.43447348	4.64398881	5.692	0.0001
CE	1	11.25134512	6.16280577	1.826	0.0706
DE	1	-17.49865488	6.16280577	-2.839	0.0054
EF	1	-11.99932744	4.68083019	-2.564	0.0117
GJ	1	-8.34146810	4.55686739	-1.831	0.0699
HJ	1	11.83839354	4.81746680	2.457	0.0156

DAY 28 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	22	61401.57974	2790.98090	8.441	0.0001
ERROR	105	34719.29526	330.65995		
C TOTAL	127	96120.87500			

ROOT MSE	18.18406	R-SQUARE	0.6388
DEP MEAN	54.59375	ADJ R-SQ	0.5631
C.V.	33.30795		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	60.79209845	3.77059867	16.123	0.0001
B1	1	-6.53125000	4.25240712	-1.536	0.1276
B2	1	4.84375000	4.25240712	1.139	0.2573
B3	1	0.46875000	4.25240712	0.110	0.9124
B4	1	1.90625000	4.25240712	0.448	0.6549
B5	1	1.71875000	4.25240712	0.404	0.6869
B6	1	-1.96875000	4.25240712	-0.463	0.6443
B7	1	2.71875000	4.25240712	0.639	0.5240
A	1	15.98437500	4.65827860	3.431	0.0009
B	1	-19.07545337	5.85365529	-3.259	0.0015
J	1	-19.82545337	5.85365529	-3.387	0.0010
AF	1	-13.56250000	4.97990930	-2.723	0.0076
AG	1	-10.71875000	4.54601443	-2.358	0.0202
BC	1	-11.00939119	5.51456583	-1.996	0.0485
BH	1	-18.93976684	5.47559314	-3.459	0.0008
BK	1	47.35006477	5.64885318	8.382	0.0001
CJ	1	15.05310881	5.51456583	2.730	0.0074
CK	1	-9.90932642	5.06941419	-1.955	0.0533
DF	1	8.31250000	4.06607891	2.044	0.0434
EH	1	-8.24319948	4.67376895	-1.764	0.0807
EK	1	-9.70336788	4.74200276	-2.046	0.0432
HJ	1	14.37273316	5.47559314	2.625	0.0100
JK	1	18.03756477	5.64885318	3.193	0.0019

DAY 29 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	24	65344.08333	2722.67014	10.241	0.0001
ERROR	103	27384.15885	265.86562		
C TOTAL	127	92728.24219			

ROOT MSE	16.30539	R-SQUARE	0.7047
DEP MEAN	49.38281	ADJ R-SQ	0.6359
C.V.	33.01834		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	70.35937500	4.64775017	15.138	0.0001
B1	1	-7.57031250	3.81307305	-1.985	0.0498
B2	1	1.92968750	3.81307305	0.506	0.6139
B3	1	-0.07031250	3.81307305	-0.018	0.9853
B4	1	3.30468750	3.81307305	0.867	0.3881
B5	1	7.42968750	3.81307305	1.948	0.0541
B6	1	-1.13281250	3.81307305	-0.297	0.7670
B7	1	-0.44531250	3.81307305	-0.117	0.9073
B	1	-28.55729167	5.32791646	-5.360	0.0001
D	1	-11.64062500	4.64775017	-2.505	0.0138
F	1	-8.25000000	4.07634656	-2.024	0.0456
J	1	-14.49479167	5.32791646	-2.721	0.0077
K	1	-13.04687500	7.20603073	-1.811	0.0731
AD	1	12.65625000	4.46541392	2.834	0.0055
AG	1	-8.06250000	3.64599520	-2.211	0.0292
BC	1	-8.65625000	4.99248454	-1.734	0.0859
BH	1	-17.22916667	4.70695956	-3.660	0.0004
BK	1	48.71875000	5.76482458	8.451	0.0001
CJ	1	8.40625000	4.99248454	1.684	0.0953
CK	1	-9.21875000	4.99248454	-1.847	0.0677
DK	1	10.84375000	5.76482458	1.881	0.0628
EK	1	-11.46875000	4.07634656	-2.813	0.0059
FK	1	11.21875000	5.76482458	1.946	0.0544
HJ	1	8.70833333	4.70695956	1.850	0.0672
[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]

DAY 30 -- REDUCED MODEL -- NO ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	63623.78125	3742.57537	13.153	0.0001
ERROR	110	31300.64844	284.55135		
C TOTAL	127	94924.42969			

ROOT MSE	16.86865	R-SQUARE	0.6703
DEP MEAN	45.22656	ADJ R-SQ	0.6193
C.V.	37.2981		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	62.89062500	4.06375944	15.476	0.0001	INTERCEPT
B1	1	-5.28906250	3.94479428	-1.341	0.1826	
B2	1	-1.03906250	3.94479428	-0.263	0.7927	
B3	1	0.64843750	3.94479428	0.164	0.8697	
B4	1	5.08593750	3.94479428	1.289	0.2000	
B5	1	7.02343750	3.94479428	1.780	0.0778	
B6	1	-1.22656250	3.94479428	-0.311	0.7564	
B7	1	-1.47656250	3.94479428	-0.374	0.7089	
B	1	-40.15625000	5.74702372	-6.987	0.0001	Filler Aircraft
H	1	-8.82812500	5.16494611	-1.709	0.0902	Spare Parts
J	1	-16.14062500	6.12163348	-2.637	0.0096	MISSILES
BH	1	-13.71875000	5.96396837	-2.300	0.0233	Fillers & Spares
BJ	1	14.90625000	5.96396837	2.499	0.0139	Fillers & Missiles
BK	1	40.65625000	5.04047324	8.066	0.0001	FILLERS & FUEL
EK	1	-13.28125000	3.90433378	-3.402	0.0009	Personnel & Fuel
GJ	1	-7.03125000	4.21716247	-1.667	0.0983	SPT EQUIP & MISSILES
HJ	1	15.28125000	5.96396837	2.562	0.0118	SPARES & MISSILES
JK	1	22.78125000	5.04047324	4.520	0.0001	MISSILES & FUEL

Appendix C: Residual Results for No-Attack Case

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                         DAY 1 -- ANALYSIS OF RESIDUALS -- NO ATTACK

                                         UNIVARIATE

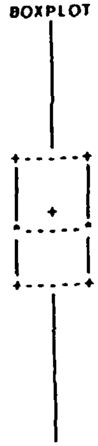
VARIABLE=YRESID          RESIDUALS

                MOMENTS                                  QUANTILES(DEF=4)                              EXTREMES

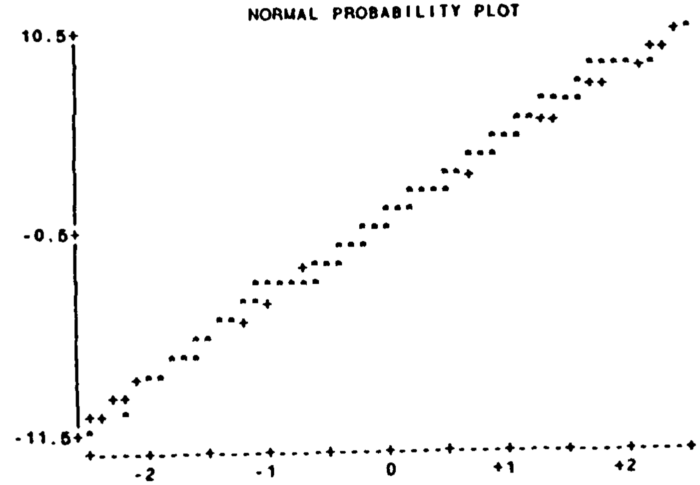
N               128  SUM WGTS         128      100% MAX    10.2401    99%     9.84048         LOWEST     HIGHEST
MEAN      2.317E-13  SUM        2.966E-11       75% Q3     3.17152    95%     7.67727       -11.0085     8.27273
STD DEV     4.28242  VARIANCE     18.3391       50% MED  -0.158361    90%     6.01903       -10.4347     8.39915
SKEWNESS  0.0109142  KURTOSIS   -0.197472       25% Q1    -3.24183    10%    -5.23565       -8.96023     8.79403
USS         2329.08  CSS          2329.08        0% MIN   -11.0085     5%    -7.50071       -8.27841     8.86222
CV            99999  STD MEAN    0.378516                              1%    -10.8421       -7.97585     10.2401
T:MEAN=0  6.121E-13  PROB>|T|           1      RANGE       21.2486
SGN RANK        -21  PROB>|S|    0.961117      Q3-Q1       6.41335
NUM ^= 0        128                            MODE       -3.77983
D:NORMAL  0.0398939  PROB>D          >.15

STEM LEAF                       #
  10 2                          1
   9
   8 23489                      5
   7 1                          1
   6 001234                     6
   5 03456                      5
   4 55688                      5
   3 1224457789                10
   2 00379                      5
   1 00122224468899            14
   0 3444455779                10
  -0 8554332211                10
  -1 7766654221000             13
  -2 98644211                   8
  -3 98888766655433210         17
  -4 96551                      5
  -5 9552                       4
  -6 52                         2
  -7 55                         2
  -8 30                         2
  -9 0                          1
 -10 4                          1
 -11 0                          1
     ----+----+----+----+
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 2 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	5.884E-15	SUM	7.532E-13
STD DEV	12.2079	VARIANCE	149.032
SKEWNESS	-0.92171	KURTOSIS	1.77317
USS	18927.1	CSS	18927.1
CV	99999	STD MEAN	1.07903
T:MEAN=0	5.453E-15	PROB>|T|	1
SGN RANK	364	PROB>|S|	0.381757
NUM ^= 0	128		
D:NORMAL	0.111275	PROB>D	<.01

QUANTILES(DEF=4)

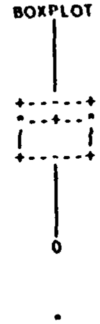
100% MAX	28.4115	99%	28.2304
75% Q3	8.23177	95%	18.82
50% MED	2.13261	90%	12.125
25% Q1	-6.47917	10%	-16.9838
0% MIN	-50.7917	5%	-23.0437
		1%	-45.2635
RANGE	79.2031		
Q3-Q1	14.7109		
MODE	-11.4635		

EXTREMES

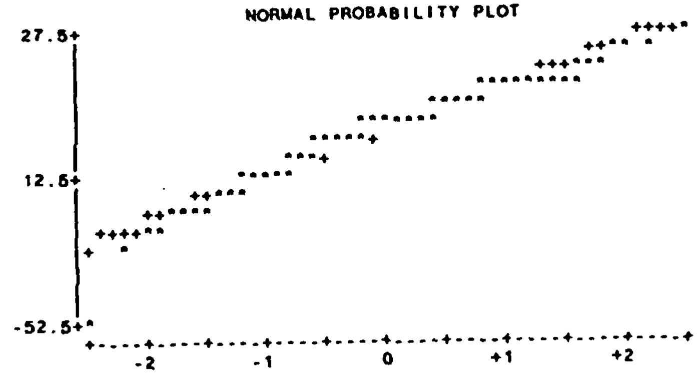
LOWEST	HIGHEST
-50.7917	19.4583
-31.7292	20.25
-26.3229	20.7865
-26.6979	20.8906
-24.9167	28.4115

```
STEM LEAF                                  #
   2 8                                     1
   2 011                                   3
   1 699                                   3
   1 000001111111222233344                21
   0 5555555666667778888899               22
   0 11111122222223333333444444           26
  -0 44433332222221110                    17
  -0 77777666                              8
  -1 4322222111                           10
  -1 88776665                              8
  -2 110                                   3
  -2 8755                                  4
  -3 2                                     1
  -3
  -4
  -4
  -5 1                                     1
     ----+----+----+----+----+-
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 3 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.442E-14	SUM	3.126E-12
STD DEV	10.3608	VARIANCE	107.347
SKEWNESS	-0.082952	KURTOSIS	-0.0888051
USS	13633.1	CSS	13633.1
CV	99999	STD MEAN	0.915776
T:MEAN=0	2.667E-14	PROB>|T|	1
SGN RANK	24	PROB>|S|	0.955432
NUM ^= 0	128		
D:NORMAL	0.0383904	PROB>D	>.15

QUANTILES(DEF=4)

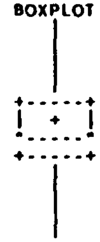
100% MAX	25.6853	99%	25.0811
75% Q3	6.91988	95%	17.7095
50% MED	-.00260417	90%	14.1072
25% Q1	-6.66647	10%	-13.6299
0% MIN	-26.8291	5%	-18.2355
		1%	-26.3556
RANGE	52.5144		
Q3-Q1	13.5864		
MODE	-26.8291		

EXTREMES

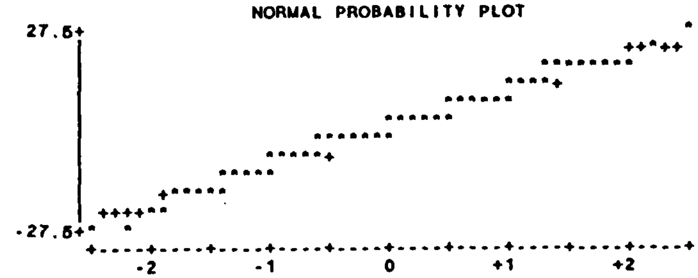
LOWEST	HIGHEST
-26.8291	18.2201
-25.1961	18.6536
-22.6697	19.3584
-20.5183	23.602
-19.3637	25.6853

```
STEM LEAF                                #
   2 6                                   1
   2 4                                   1
   1 5566788899                         10
   1 0111122334                         10
   0 5556667777778899999                19
   0 111111222223444444                 18
  -0 444443333333322211111000000000     30
  -0 888888877777665555                 18
  -1 44433222110                        11
  -1 998766                              6
  -2 31                                  2
  -2 75                                  2
     ----+----+----+----+----+----+
   MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 4 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	9.326E-15	SUM	1.194E-12
STD DEV	11.3892	VARIANCE	129.713
SKEWNESS	0.039497	KURTOSIS	0.228852
USS	16473.6	CSS	16473.6
CV	99999	STD MEAN	1.00667
T:MEAN=0	9.264E-15	PROB>|T|	1
SGN RANK	7	PROB>|S|	0.987867
NUM ^= 0	128		
D:NORMAL	0.0484107	PROB>D	>.15

QUANTILES(DEF=4)

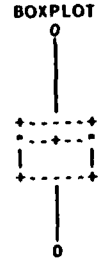
100% MAX	32.2643	99%	32.0004
75% Q3	8.4401	95%	17.9437
50% MED	0.144531	90%	13.1685
25% Q1	-6.64421	10%	-15.132
0% MIN	-29.3333	5%	-19.7743
		1%	-28.5585
RANGE	61.5977		
Q3-Q1	15.0843		
MODE	0.144531		

EXTREMES

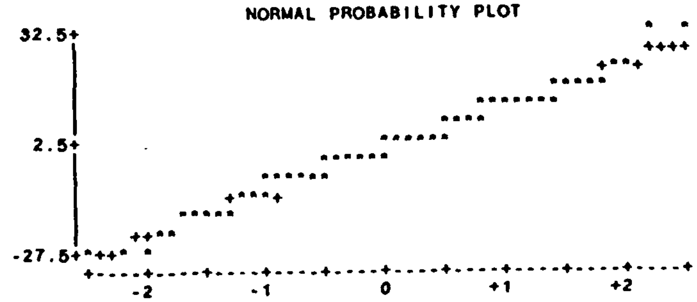
LOWEST	HIGHEST
-29.3333	18.2643
-28.8615	22.3633
-25.7865	23.957
-21.7214	31.3542
-20.0299	32.2643

```
STEM LEAF                                #
   3 12                                  2
   2
   2 24                                  2
   1 557888                              6
   1 00112222222233344                  17
   0 655677888888889999                 18
   0 11111112223333444                  17
  -0 4444444444433333322211000000       28
  -0 99998877776666555                  17
  -1 322221100                           9
  -1 9876555                             7
  -2 2000                                4
  -2 976                                 3
     ----+----+----+----+----+---
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 6 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.554E-14	SUM	1.990E-12
STD DEV	12.0204	VARIANCE	144.489
SKEWNESS	-0.330004	KURTOSIS	0.318079
USS	18350.1	CSS	18350.1
CV	99999	STD MEAN	1.06246
T:MEAN=0	1.463E-14	PROB>|T|	1
SGN RANK	157	PROB>|S|	0.709758
NUM ^= 0	128		
D:NORMAL	0.056046	PROB>D	>.15

QUANTILES(DEF=4)

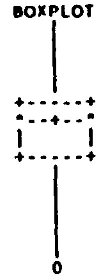
100% MAX	29.1547	99%	28.1651
75% Q3	8.69519	95%	18.2828
50% MED	1.12945	90%	14.4
25% Q1	-7.58232	10%	-16.701
0% MIN	-36.815	5%	-22.938
		1%	-35.3037
RANGE	65.9698		
Q3-Q1	16.2775		
MODE	-36.815		

EXTREMES

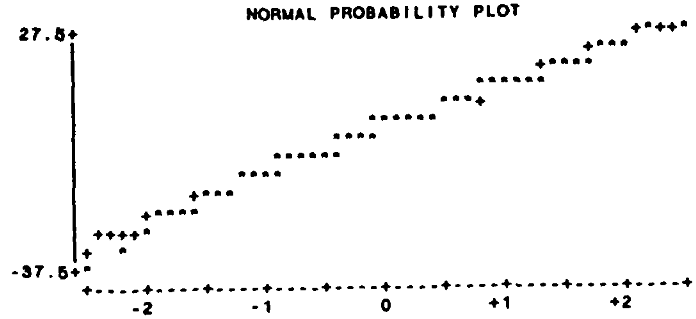
LOWEST	HIGHEST
-36.815	21.0316
-31.6037	22.1774
-27.6327	24.7589
-24.3385	25.7423
-23.7443	29.1547

```
STEM LEAF                          #
   2 569                           3
   2 12                            2
   1 5677889                       7
   1 00011111112233344            17
   0 5557778889999                13
   0 1111222222333333334444444    25
  -0 433333222210000              15
  -0 9988888877777776665555       22
  -1 43221110000                  11
  -1 8887                          4
  -2 443310                        6
  -2 8                             1
  -3 2                             1
  -3 7                             1
     ----+----+----+----+----+
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 8 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

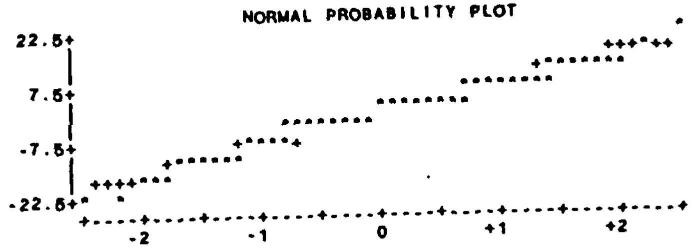
```
VARIABLE=YRESID          RESIDUALS

                  MOMENTS                                         QUANTILES(DEF=4)                                    EXTREMES

N               128  SUM WGTS         128      100% MAX    22.4341     99%    20.8014              LOWEST    HIGHEST
MEAN      2.842E-14  SUM        3.638E-12       75% Q3     5.29898     95%    12.1594            -23.8474    12.6509
STD DEV     8.00798  VARIANCE     64.1278       50% MED   0.459594     90%    9.38428            -21.8397    13.1432
SKEWNESS  -0.404062  KURTOSIS     0.49866       25% Q1    -3.86861     10%    -11.508            -18.8289    14.1123
USS         8144.23  CSS          8144.23        0% MIN   -23.8474      5%   -14.4923            -17.2922    18.8044
CV            99999  STD MEAN    0.707812                               1%   -23.2652             -17.238    22.4341
T:MEAN=0  4.015E-14  PROB>|T|           1      RANGE       46.2815
SGN RANK        222  PROB>|S|     0.59836      Q3-Q1        9.1676
NUM ^= 0        128                            MODE       -23.8474
D:NORMAL  0.0697883  PROB>D         0.128

STEM LEAF                                          #        BOXPLOT
   2 2                                             1           0
   1 7                                             1           |
   1 0001123334                                   10           |
   0 55555556666677888888899999                   26        +-----+
   0 1112222222223333333444444                    25        *--+--*
  -0 44444333333333222222222211110000000          35        +-----+
  -0 88877777666555                               14           |
  -1 4433321111                                   10           |
  -1 9775                                          4           0
  -2 42                                            2           0
     ----+----+----+----+----+----+----+
  MULTIPLY STEM.LEAF BY 10**+01
```

NORMAL PROBABILITY PLOT



DAY 7 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.776E-14	SUM	2.274E-12
STD DEV	12.7771	VARIANCE	163.255
SKEWNESS	-0.570266	KURTOSIS	2.69448
USS	20733.3	CSS	20733.3
CV	99999	STD MEAN	1.12935
T:MEAN=0	1.573E-14	PROB>|T|	1
SGN RANK	91	PROB>|S|	0.829594
NUM ^= 0	128		
D:NORMAL	0.0465664	PROB>D	>.15

QUANTILES(DEF=4)

100% MAX	36.6836	99%	34.3706
75% Q3	8.74706	95%	19.6887
50% MED	0.0800203	90%	16.1432
25% Q1	-7.9492	10%	-15.1411
0% MIN	-56.3241	5%	-19.0463
		1%	-49.8072
RANGE	97.0079		
Q3-Q1	16.6963		
MODE	-56.3241		

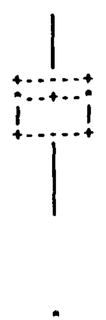
EXTREMES

LOWEST	HIGHEST
-56.3241	19.9366
-26.9556	20.4662
-23.6544	23.0331
-21.5019	23.6109
-21.2455	36.6836

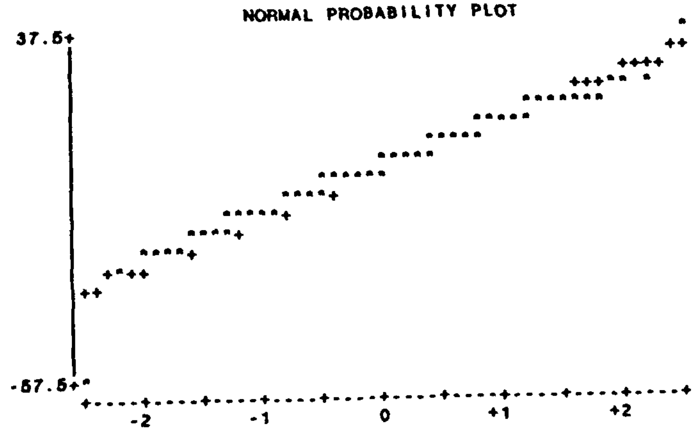
```
STEM LEAF                        #
   3 9                           1
   3
   2
   2 000034                      6
   1 5555677777                 10
   1 000011233344               12
   0 5556666788899999           16
   0 1122222334444444           16
  -0 4444333322222211100000     22
  -0 9998888887665555555        19
  -1 4443321110                 10
  -1 8777776555                 10
  -2 4210                        4
  -2 9                           1
  -3
  -3
  -4
  -4
  -5
  -5 8                           1
     ----+----+----+----+--
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT

0



NORMAL PROBABILITY PLOT



DAY 6 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.243E-14	SUM	1.592E-12
STD DEV	19.3027	VARIANCE	372.595
SKEWNESS	-0.792626	KURTOSIS	1.70299
USS	47319.5	CSS	47319.5
CV	99999	STD MEAN	1.70613
T:MEAN=0	7.286E-15	PROB>|T|	1
SGN RANK	260	PROB>|S|	0.537149
NUM ^= 0	128		
D:NORMAL	0.066159	PROB>D	>.15

QUANTILES(DEF=4)

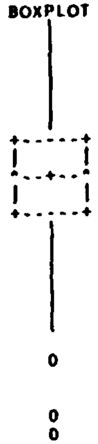
100% MAX	39.6675	99%	39.4082
75% Q3	11.7641	95%	29.0507
50% MED	1.56622	90%	24.3264
25% Q1	-9.63937	10%	-22.0495
0% MIN	-67.63	5%	-32.7261
		1%	-66.3325
RANGE	107.318		
Q3-Q1	21.4035		
MODE	-67.63		

EXTREMES

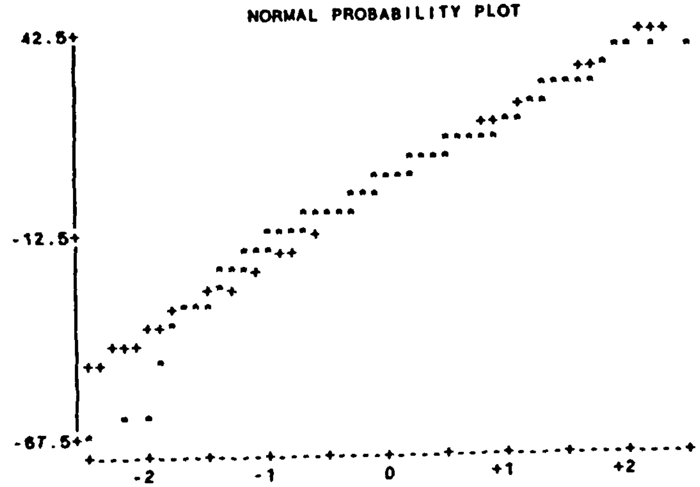
LOWEST	HIGHEST
-67.63	32.2433
-63.1557	35.2818
-61.3594	36.1881
-46.665	36.7243
-39.12	39.6675

```
STEM LEAF                        #
   4 0                           1
   3 569                         3
   3 2                           1
   2 5557699                     7
   2 03444                       5
   1 5667766                     7
   1 00001111222223344          17
   0 55566777788699             14
   0 111222233344               12
  -0 44333222210000             14
  -0 99999877788665             14
  -1 44443311100                11
  -1 9977655                     7
  -2 43200                       5
  -2 8                           1
  -3 3221                        4
  -3 9                           1
  -4
  -4 7                           1
  -5
  -5
  -6 31                          2
  -6 8                           1
     ----+----+----+----+
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 9 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	4.441E-15	SUM	5.684E-13
STD DEV	21.8517	VARIANCE	477.498
SKEWNESS	-0.178982	KURTOSIS	0.717934
USS	60642	CSS	60642
CV	99999	STD MEAN	1.93143
T:MEAN=0	2.299E-15	PROB>|T|	1
SGN RANK	42	PROB>|S|	0.921382
NUM ^= 0	128		
D:NORMAL	0.0890217	PROB>D	0.014

QUANTILES(DEF=4)

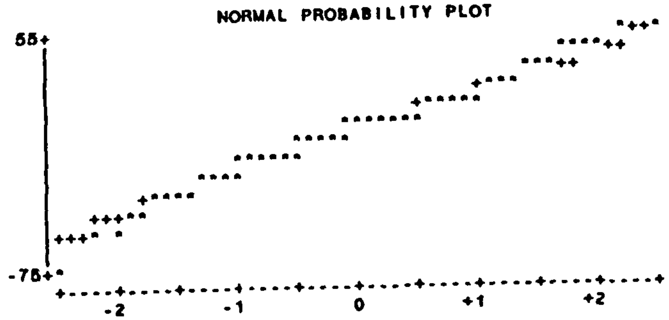
100% MAX	53.7422	99%	53.0478
75% Q3	11.6992	95%	41.7057
50% MED	2.8457	90%	28.1867
25% Q1	-13.3389	10%	-28.3519
0% MIN	-71.1719	5%	-38.2998
		1%	-65.9904
RANGE	124.914		
Q3-Q1	25.0381		
MODE	-71.1719		

EXTREMES

LOWEST	HIGHEST
-71.1719	44.832
-53.3047	44.9219
-50.6875	46.0742
-49.2852	51.3477
-40.207	53.7422

```
STEM LEAF                                   #    BOXPLOT
   5 14                                     2       0
   4 03556                                  5       |
   3 1347                                   4       |
   2 11224689                               8       |
   1 0001122223344444566                   19    +-----+
   0 1222334444444455667777778899999       31    *--+--*
  -0 9988777665553322211                   19    |     |
  -1 9877655444332210000                   19    +-----+
  -2 9877542110                            10       |
  -3 982111                                 6       |
  -4 90                                     2       0
  -5 31                                     2
  -6
  -7 1                                      1       0
     ----+----+----+----+----+----+-
 MULTIPLY STEM.LEAF BY 10**+01
```

NORMAL PROBABILITY PLOT



DAY 10 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

```
VARIABLE=YRESID          RESIDUALS

                          MOMENTS

N                 128  SUM WGTS            128
MEAN        2.798E-14  SUM           3.581E-12
STD DEV       10.2892  VARIANCE        105.869
SKEWNESS   -0.0470851  KURTOSIS      -0.209065
USS           13445.3  CSS             13445.3
CV              99999  STD MEAN       0.909449
T:MEAN=0    3.078E-14  PROB>|T|              1
SGN RANK           22  PROB>|S|       0.959222
NUM ^= 0          128
D:NORMAL      0.03213  PROB>D             >.15
```

```
                     QUANTILES(DEF=4)

100% MAX    24.2483        99%      24.2446
 75% Q3     7.59388        95%      17.2678
 50% MED   0.306599        90%      13.0628
 25% Q1    -6.76007        10%     -14.1232
  0% MIN   -27.7621         5%     -18.2992
                            1%     -25.6444

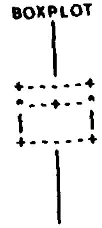
RANGE       52.0104
Q3-Q1       14.3539
MODE       -27.7621
```

```
          EXTREMES

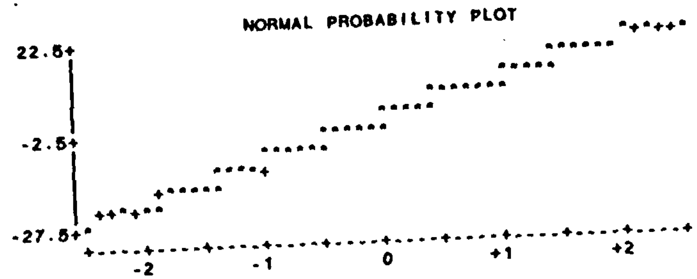
   LOWEST      HIGHEST
 -27.7621      18.0902
 -20.4597      18.9793
 -20.4375      21.8014
 -20.2251      24.2357
 -19.3218      24.2483
```

```
STEM LEAF                                #
   2 244                                 3
   1 6667789                             7
   1 000111333334                       12
   0 55555666666778888889999            23
   0 11111222222333344                  17
  -0 44444433332222210000000            23
  -0 999877777777776666555              21
  -1 44443220000                        11
  -1 9987655                             7
  -2 000                                 3
  -2 8                                   1
     ----+----+----+----+---
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 11 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.199E-14	SUM	1.535E-12
STD DEV	13.0006	VARIANCE	169.016
SKEWNESS	-0.411631	KURTOSIS	1.57991
USS	21465	CSS	21465
CV	99999	STD MEAN	1.1491
T:MEAN=0	1.043E-14	PROB>|T|	1
SGN RANK	110	PROB>|S|	0.794549
NUM ^= 0	128		
D:NORMAL	0.0439562	PROB>D	>.15

QUANTILES(DEF=4)

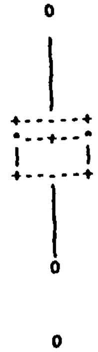
100% MAX	36.1797	99%	34.0002
75% Q3	8.69531	95%	19.5566
50% MED	0.914063	90%	15.5453
25% Q1	-7.81836	10%	-14.6531
0% MIN	-51.2891	5%	-21.2402
		1%	-46.3477
RANGE	87.4688		
Q3-Q1	16.5137		
MODE	-7.76562		

EXTREMES

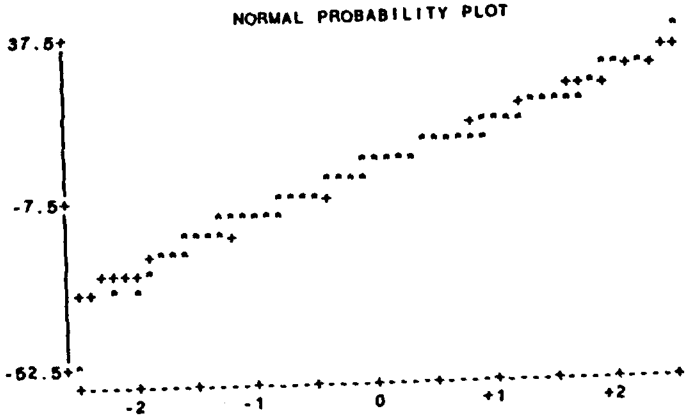
LOWEST	HIGHEST
-51.2891	20.4922
-34.25	25.6953
-30.0703	28.5781
-26.1641	28.6641
-23.4687	36.1797

```
STEM LEAF                    #
 3 6                         1
 3
 2 699                       3
 2 00                        2
 1 55778999                  8
 1 00111233334              11
 0 555667778888899999999    21
 0 1111111222333444444      19
-0 44444433333211000000     20
-0 9998888887776555         16
-1 44333221111110           14
-1 988755                    6
-2 311                       3
-2 6                         1
-3 40                        2
-3
-4
-4
-5 1                         1
   ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 12 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.243E-14	SUM	1.592E-12
STD DEV	13.2754	VARIANCE	176.236
SKEWNESS	-0.200831	KURTOSIS	-0.10571
USS	22362	CSS	22362
CV	99999	STD MEAN	1.17339
T:MEAN=0	1.060E-14	PROB>|T|	1
SGN RANK	50	PROB>|S|	0.906291
NUM ^= 0	128		
D:NORMAL	0.0531367	PROB>D	>.15

QUANTILES(DEF=4)

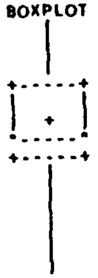
100% MAX	29.376	99%	27.9206
75% Q3	10.4745	95%	21.6462
50% MED	-0.059375	90%	18.4096
25% Q1	-6.38958	10%	-16.299
0% MIN	-35.3698	5%	-22.7369
		1%	-35.1046
RANGE	64.7458		
Q3-Q1	16.8641		
MODE	-4.08021		

EXTREMES

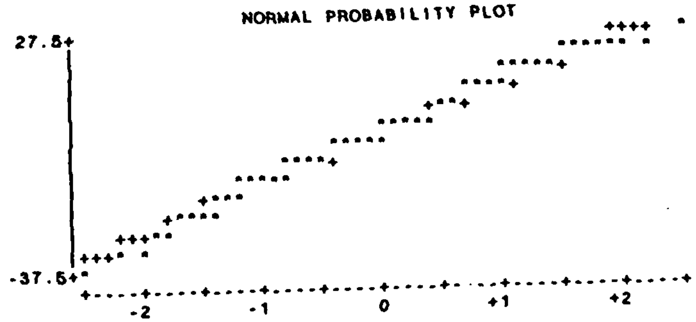
LOWEST	HIGHEST
-35.3698	22.9094
-34.4552	23.1719
-30.9323	23.8448
-27.924	24.3573
-27.4656	29.376

```
STEM LEAF                                 #
   2 9                                    1
   2 12223344                             8
   1 555667788999                        12
   1 011112333444                        12
   0 555666779                            9
   0 111222233334444                     15
  -0 44444332222111111100000000000       29
  -0 9888888877665                       13
  -1 44433322111000                      14
  -1 66665                                5
  -2 32111                                5
  -2 87                                   2
  -3 41                                   2
  -3 5                                    1
     ----+----+----+----+----+----
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 13 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.643E-14	SUM	2.103E-12
STD DEV	11.5228	VARIANCE	132.775
SKEWNESS	-0.519741	KURTOSIS	1.67198
USS	16862.4	CSS	16862.4
CV	99999	STD MEAN	1.01848
T:MEAN=0	1.613E-14	PROB>|T|	1
SGN RANK	50	PROB>|S|	0.906291
NUM ^= 0	128		
D:NORMAL	0.0508881	PROB>D	>.15

QUANTILES(DEF=4)

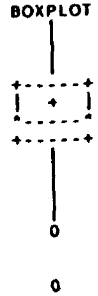
100% MAX	21.8936	99%	21.6502
75% Q3	8.4988	95%	19.2175
50% MED	-0.707689	90%	16.1566
25% Q1	-7.16627	10%	-13.3806
0% MIN	-49.0686	5%	-15.5765
		1%	-44.2582
RANGE	70.9623		
Q3-Q1	15.6651		
MODE	-49.0686		

EXTREMES

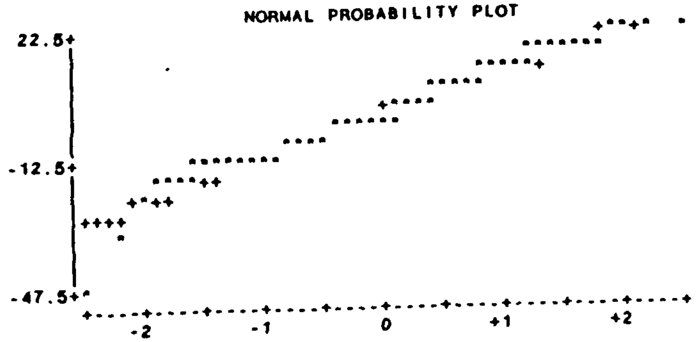
LOWEST	HIGHEST
-49.0686	19.4939
-32.4809	20.3407
-20.4017	20.4073
-16.2227	21.7439
-16.1665	21.8936

```
STEM LEAF                              #
   2 0022                              4
   1 56666799999                      11
   1 0001112223344                    13
   0 55555555666689999                17
   0 1122234444444                    13
  -0 44444332222222222211100000       26
  -0 999887776666666555               18
  -1 4444433333332111000              19
  -1 6665                              4
  -2 0                                 1
  -2
  -3 2                                 1
  -3
  -4
  -4 9                                 1
     ----+----+----+----+----+-
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



```
                         DAY 14 -- ANALYSIS OF RESIDUALS -- NO ATTACK
                                        UNIVARIATE

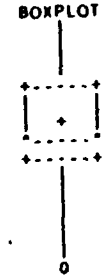
VARIABLE=YRESID          RESIDUALS

                MOMENTS                                    QUANTILES(DEF=4)                                 EXTREMES

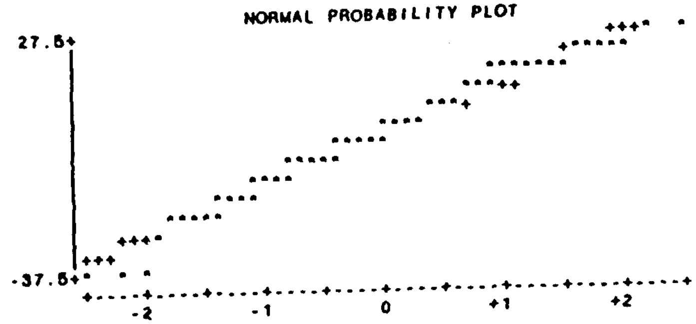
N                 128  SUM WGTS          128     100% MAX    27.9141     99%    27.3341          LOWEST     HIGHEST
MEAN        9.770E-15  SUM         1.251E-12      75% Q3     10.3255     95%    20.9266         -37.737     21.0755
STD DEV       13.6284  VARIANCE      185.733      50% MED  -0.309696     90%    18.3849        -37.3568     22.6224
SKEWNESS    -0.312665  KURTOSIS    -0.030611      25% Q1    -8.82943     10%    -18.669        -36.8672     24.6569
USS           23566.1  CSS           23566.1       0% MIN    -37.737      5%   -22.0529        -26.8672     25.9141
CV              99999  STD MEAN      1.20459                              1%   -37.6267         -23.487     27.9141
T:MEAN=0    8.111E-15  PROB>|T|            1     RANGE        65.651
SGN RANK        101.5  PROB>|S|      0.81018     Q3-Q1       19.1549
NUM ^= 0          128                            MODE       -8.65385
D:NORMAL    0.0464361  PROB>D           >.15

STEM LEAF                          #
   2 566                           3
   2 11113                         5
   1 566666778888999               6
   1 0011112233                   10
   0 5566666778888 9              14
   0 112233334444                 12
  -0 44444322222211110000000      23
  -0 99988877777765555            17
  -1 4443321110                   10
  -1 987765555                     9
  -2 331111                        8
  -2 7                             1
  -3
  -3 877                           3
     ----+----+----+----+---
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 15 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.510E-14	SUM	1.933E-12
STD DEV	11.9536	VARIANCE	142.889
SKEWNESS	-0.111485	KURTOSIS	-0.485952
USS	18146.9	CSS	18146.9
CV	99999	STD MEAN	1.05656
T:MEAN=0	1.429E-14	PROB>|T|	1
SGN RANK	45	PROB>|S|	0.915719
NUM ^= 0	128		
D:NORMAL	0.0518893	PROB>D	>.15

QUANTILES(DEF=4)

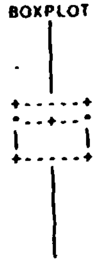
100% MAX	26.4016	99%	25.6983
75% Q3	8.37773	95%	19.298
50% MED	1.20937	90%	15.89
25% Q1	-9.4625	10%	-15.5756
0% MIN	-31.0547	5%	-20.4903
		1%	-28.9975
RANGE	57.4563		
Q3-Q1	17.8402		
MODE	-13.4437		

EXTREMES

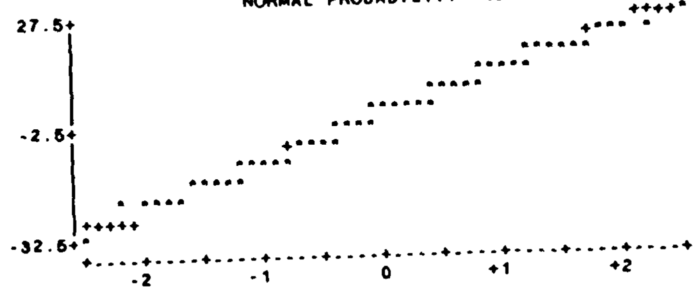
LOWEST	HIGHEST
-31.0547	22.0688
-23.9809	22.4786
-23.7531	22.7984
-23.3172	23.9766
-23.3047	26.4016

```
STEM LEAF                          #
   2 6                             1
   2 02234                         5
   1 66668899                      8
   1 011123334444                 12
   0 56667777788888888999         20
   0 1111111122233333444444       22
  -0 4444333332222200             16
  -0 988887777655                 12
  -1 44333322221111000            17
  -1 98776555                      8
  -2 443310                        6
  -2
  -3 1                             1
     ----+----+----+----+--
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 16 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.288E-14	SUM	1.648E-12
STD DEV	12.1359	VARIANCE	147.279
SKEWNESS	0.060041	KURTOSIS	-0.15954
USS	18704.4	CSS	18704.4
CV	99999	STD MEAN	1.07267
T:MEAN=0	1.201E-14	PROB>|T|	1
SGN RANK	-8	PROB>|S|	-0.98577
NUM ^= 0	128		
D:NORMAL	0.0716189	PROB>D	0.105

QUANTILES(DEF=4)

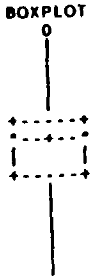
100% MAX	30.8033	99%	29.6537
75% Q3	6.4481	95%	22.0041
50% MED	0.971668	90%	16.3747
25% Q1	-8.91935	10%	-14.2481
0% MIN	-31.6656	5%	-19.4309
		1%	-30.0585
RANGE	62.469		
Q3-Q1	15.3674		
MODE	-31.6656		

EXTREMES

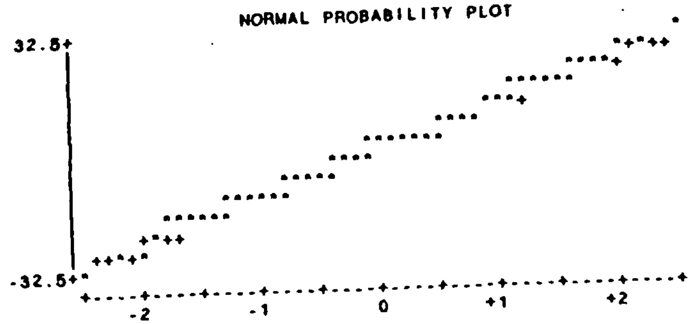
LOWEST	HIGHEST
-31.6656	22.8818
-26.1238	23.9112
-25.2214	26.1695
-24.0627	26.6391
-19.6565	30.8033

```
STEM LEAF                          #
   3 1                             1
   2 67                            2
   2 02234                         5
   1 666667889                     9
   1 001123444                     9
   0 55555556666678889            17
   0 11111111222222333334444      23
  -0 444322211100000              15
  -0 999888887776666555           18
  -1 44444333333222100            17
  -1 987765                        6
  -2 400                           3
  -2 65                            2
  -3 2                             1
     ----+----+----+----+---
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 17 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.398E-14	SUM	3.070E-12
STD DEV	11.0727	VARIANCE	122.604
SKEWNESS	0.17756	KURTOSIS	0.103748
USS	15570.7	CSS	15570.7
CV	99999	STD MEAN	0.978694
T:MEAN=0	2.450E-14	PROB>|T|	1
SGN RANK	-42	PROB>|S|	0.921362
NUM ^= 0	128		
D:NORMAL	0.03508	PROB>D	>.15

QUANTILES(DEF=4)

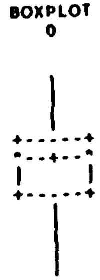
100% MAX	36.5155	99%	32.9688
75% Q3	6.92398	95%	17.7083
50% MED	0.731277	90%	14.9816
25% Q1	-8.13967	10%	-14.5037
0% MIN	-27.3562	5%	-17.9841
		1%	-26.2524
RANGE	63.8717		
Q3-Q1	15.0637		
MODE	-27.3562		

EXTREMES

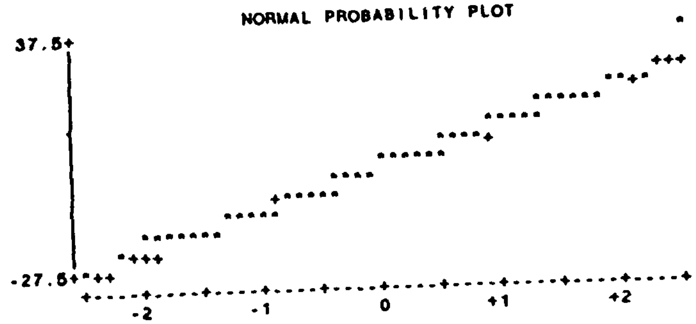
LOWEST	HIGHEST
-27.3562	18.3873
-23.5501	21.0916
-19.4239	22.8831
-18.7722	24.2854
-18.4707	36.5155

```
STEM LEAF                                   #
   3 7                                      1
   3
   2
   2 134                                    3
   1 566667788                              9
   1 0001112222233                         13
   0 555557777778889 9                     16
   0 11111222222333333444444               23
  -0 44444333221110000                     17
  -0 9999988877666655555                   19
  -1 444322111111000                       15
  -1 9988888765                            10
  -2 4                                      1
  -2 7                                      1
     ----+----+----+----+---
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 18 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.087E-14	SUM	2.672E-12
STD DEV	10.1186	VARIANCE	102.385
SKEWNESS	-0.0711399	KURTOSIS	-0.364679
USS	13002.9	CSS	13002.9
CV	99999	STD MEAN	0.894363
T:MEAN=0	2.334E-14	PROB>|T|	1
SGN RANK	11	PROB>|S|	0.980078
NUM ^= 0	128		
D:NORMAL	0.0465947	PROB>D	>.15

QUANTILES(DEF=4)

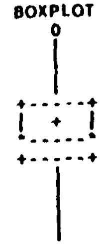
100% MAX	27.0989	99%	24.8898
75% Q3	6.51924	95%	16.2246
50% MED	-0.225379	90%	13.1377
25% Q1	-6.85601	10%	-13.1427
0% MIN	-26.192	5%	-18.0963
		1%	-24.6787
RANGE	53.2909		
Q3-Q1	13.3772		
MODE	-26.192		

EXTREMES

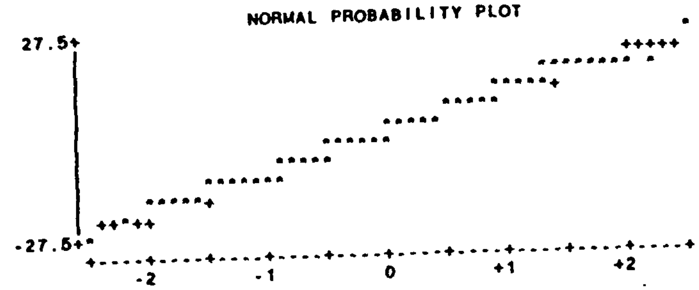
LOWEST	HIGHEST
-26.192	16.3194
-20.9738	17.0262
-19.841	17.8887
-18.9448	16.7919
-18.72	27.0989

```
STEM LEAF                             #
   2 7                                1
   2
   1 55566666789                     11
   1 01112222233                     11
   0 55555555666667778889999         23
   0 11112222234444                  14
  -0 44333222222111111111000000      26
  -0 99887777766665555               17
  -1 44433332221100000               17
  -1 998875                           6
  -2 10                               2
  -2 6                                1
     ----+----+----+----+----+
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 19 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

```
VARIABLE=YRESID          RESIDUALS

                  MOMENTS

N                 128  SUM WGTS          128
MEAN        2.753E-14  SUM         3.524E-12
STD DEV       15.9607  VARIANCE      254.743
SKEWNESS    -0.410388  KURTOSIS      1.57466
USS           32352.4  CSS           32352.4
CV              99999  STD MEAN      1.41074
T:MEAN=0    1.952E-14  PROB>|T|            1
SGN RANK           47  PROB>|S|     0.911946
NUM ^= 0          128
D:NORMAL    0.0664604  PROB>D           >.15

                    QUANTILES(DEF=4)

100% MAX     39.0892       99%     38.8606
 75% Q3      10.9574       95%     26.1265
 50% MED   -0.176723       90%     19.2904
 25% Q1     -9.77412       10%    -18.2236
  0% MIN    -56.8668        5%    -24.7263
                            1%    -56.1422

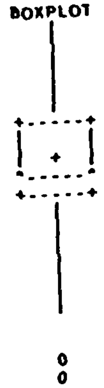
RANGE        95.9759
Q3-Q1        20.7315
MODE        -56.8668

            EXTREMES

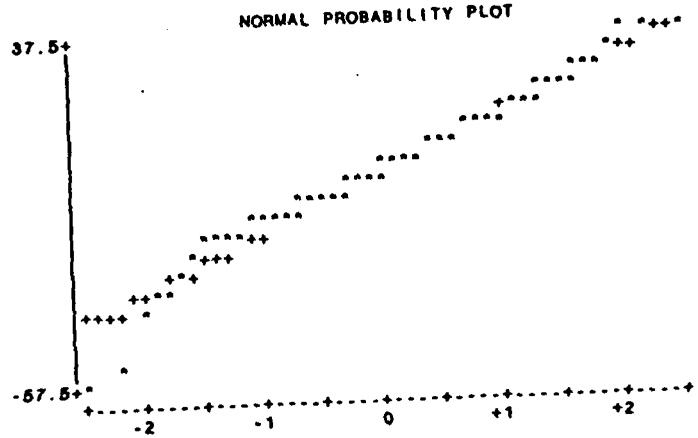
     LOWEST     HIGHEST
   -56.8668     27.5356
   -54.3193     31.0844
   -37.4876     35.6745
   -32.1482     38.3009
    -31.894     39.0892

STEM LEAF                      #
   3 689                       3
   3 1                         1
   2 55678                     5
   2 113                       3
   1 5677889                   7
   1 11111123333344           14
   0 55567778899999           14
   0 111222222334444          15
  -0 444444332222110000       18
  -0 9777777776666555         16
  -1 44443322221100           14
  -1 6665555                   7
  -2 43000                     5
  -2 5                         1
  -3 22                        2
  -3 7                         1
  -4
  -4
  -5 4                         1
  -5 7                         1
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 20 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.998E-14	SUM	2.558E-12
STD DEV	12.5414	VARIANCE	157.288
SKEWNESS	-0.0266719	KURTOSIS	-0.0499499
USS	19975.6	CSS	19975.6
CV	99999	STD MEAN	1.10852
T:MEAN=0	1.803E-14	PROB>|T|	1
SGN RANK	49	PROB>|S|	0.908175
NUM ^= 0	128		
D:NORMAL	0.0551034	PROB>D	>.15

QUANTILES(DEF=4)

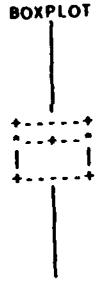
100% MAX	31.5321	99%	31.3668
75% Q3	7.52072	95%	20.5067
50% MED	1.54644	90%	18.1677
25% Q1	-8.85166	10%	-17.5704
0% MIN	-32.8891	5%	-21.9626
		1%	-30.9869
RANGE	64.4211		
Q3-Q1	16.3726		
MODE	-32.8891		

EXTREMES

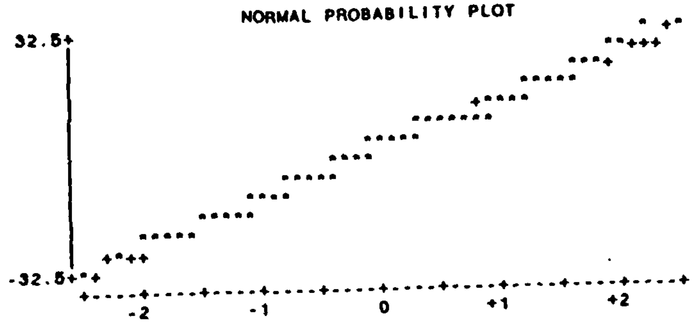
LOWEST	HIGHEST
-32.8891	20.6792
-26.3298	25.5099
-24.8502	28.7033
-23.9123	30.9621
-22.903	31.5321

```
STEM LEAF                              #
   3 12                                2
   2 89                                2
   2 0011                              4
   1 55667788                          8
   1 01123333                          8
   0 55555566667777788889999          23
   0 1222222223333344444              16
  -0 43332222211100000                17
  -0 999998887666555555               18
  -1 44332111000                      11
  -1 99877766                          8
  -2 432210                            6
  -2 65                                2
  -3 3                                 1
     ----+----+----+----+---
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 21 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

```
VARIABLE=YRESID          RESIDUALS

                 MOMENTS

N               128  SUM WGTS          128
MEAN      3.286E-14  SUM         4.206E-12
STD DEV     11.0312  VARIANCE      121.687
SKEWNESS   0.197588  KURTOSIS    -0.652666
USS         15454.2  CSS           15454.2
CV            99999  STD MEAN     0.975027
T:MEAN=0  3.370E-14  PROB>|T|            1
SGN RANK        -74  PROB>|S|     0.861241
NUM ^= 0        128
D:NORMAL  0.0574261  PROB>D           >.15

             QUANTILES(DEF=4)

100% MAX    28.3158     99%    27.0052
 75% Q3      9.2044     95%    18.4616
 50% MED   -1.13654     90%      15.41
 25% Q1    -8.24197     10%   -13.9412
  0% MIN   -20.6787      5%   -18.1288
                         1%   -20.5393

RANGE       48.9945
Q3-Q1       17.4464
MODE       -20.6787

        EXTREMES

   LOWEST    HIGHEST
 -20.6787    18.8126
  -20.198     19.256
 -19.7158    23.5267
 -19.2453    23.7963
 -18.9578    28.3158

STEM LEAF                        #     BOXPLOT
   2 8                           1        |
   2 44                          2        |
   1 5555667778899              13        |
   1 0000011222222233           16     +-----+
   0 5566667778889              13     |  +  |
   0 111233333344               12     *-----*
  -0 4444333333322211111110000  25     +-----+
  -0 99998888777777666655       20        |
  -1 444332211110000            15        |
  -1 999877666                   9        |
  -2 100                         3
     ----+----+----+----+----+
  MULTIPLY STEM.LEAF BY 10**+01

                   NORMAL PROBABILITY PLOT
  27.5+                                                  ++*
      |                                             +*+*
      |                                      *********
      |                                  *****+
      |                              *****+
   2.5+                          +****
      |                     ******
      |                 ******
      |             *****
      |     ********
 -22.5+*   *+++
       +----+----+----+----+----+----+----+----+----+----+
           -2        -1         0        +1        +2
```

DAY 22 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID   RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.021E-14	SUM	1.307E-12
STD DEV	11.755	VARIANCE	138.18
SKEWNESS	0.0790411	KURTOSIS	0.223052
USS	17548.8	CSS	17548.8
CV	99999	STD MEAN	1.039
T:MEAN=0	9.831E-15	PROB>|T|	1
SGN RANK	-29	PROB>|S|	0.945983
NUM ^= 0	128		
D:NORMAL	0.0358772	PROB>D	>.15

QUANTILES(DEF=4)

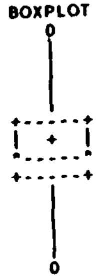
100% MAX	34.4786	99%	32.7003
75% Q3	7.21094	95%	20.2109
50% MED	-0.398437	90%	14.8047
25% Q1	-7.81719	10%	-14.9047
0% MIN	-32.0859	5%	-18.95
		1%	-30.3369
RANGE	66.5625		
Q3-Q1	14.8281		
MODE	-13.8484		

EXTREMES

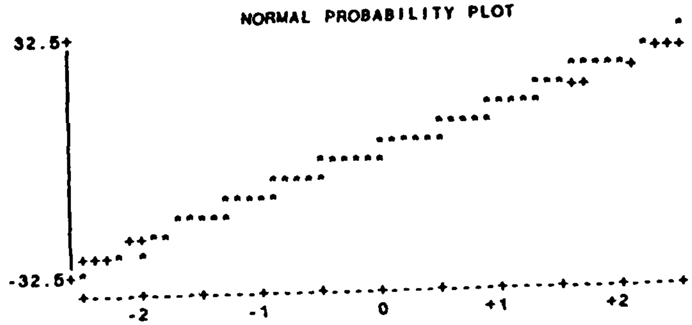
LOWEST	HIGHEST
-32.0859	20.3828
-26.0547	22.3203
-25.4297	23.3203
-23.9297	26.3516
-22.8359	34.4786

```
STEM LEAF                        #
   3 4                           1
   2 8                           1
   2 000023                      6
   1 5555899                     7
   1 0000122344                 10
   0 5555566777777788999        19
   0 11111222223334444          17
  -0 4444444333222111110000     22
  -0 9999988887777855555555     22
  -1 4444331110                 10
  -1 8788855                     7
  -2 430                         3
  -2 85                          2
  -3 2                           1
     ----+----+----+----+--
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



```
DAY 23 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID          RESIDUALS

               MOMENTS

N                128  SUM WGTS          128
MEAN       2.398E-14  SUM         3.070E-12
STD DEV      11.0249  VARIANCE      121.546
SKEWNESS   -0.187981  KURTOSIS    -0.325812
USS          15436.6  CSS           15436.6
CV             99999  STD MEAN      0.97447
T:MEAN=0   2.481E-14  PROB>|T|            1
SGN RANK          50  PROB>|S|     0.908291
NUM ^= 0         128
D:NORMAL   0.0348818  PROB>D           >.15

STEM LEAF                               #
   2 000                                3
   1 556667779999                      12
   1 0011222333                        10
   0 555566666677788899999 9           21
   0 11112222234444                    14
  -0 44444433332222211111111000        26
  -0 999988887666555555                18
  -1 44332221110                       11
  -1 966655                             6
  -2 321100                             6
  -2
  -3 2                                  1
     ----+----+----+----+----+-
MULTIPLY STEM.LEAF BY 10**+01

          QUANTILES(DEF=4)

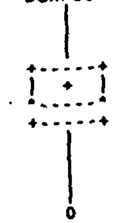
100% MAX   20.2106     99%    20.083
 75% Q3    8.16242     95%   19.1222
 50% MED  -0.69144     90%    16.286
 25% Q1   -7.67473     10%  -14.7666
  0% MIN  -32.4041      5%   -20.093
                        1%  -29.5326

RANGE      52.6147
Q3-Q1      15.8371
MODE      -32.4041

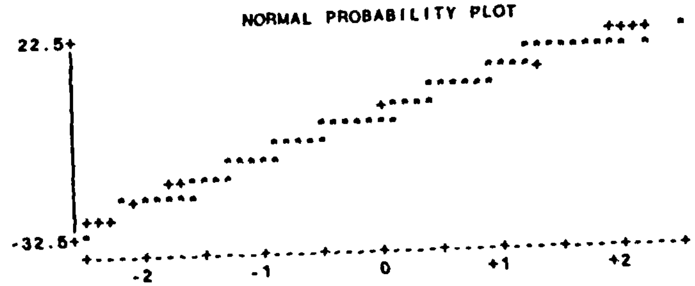
          EXTREMES

   LOWEST    HIGHEST
 -32.4041    19.2555
 -22.5024    19.3483
 -21.9455    19.6834
 -21.3918    19.7708
 -20.7132    20.2106
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 24 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.753E-14	SUM	3.524E-12
STD DEV	11.4738	VARIANCE	131.649
SKEWNESS	-0.520858	KURTOSIS	1.82848
USS	16719.4	CSS	16719.4
CV	99999	STD MEAN	1.01415
T:MEAN=0	2.715E-14	PROB>|T|	1
SGN RANK	80	PROB>|S|	0.850043
NUM ^= 0	128		
D:NORMAL	0.0525585	PROB>D	>.15

QUANTILES(DEF=4)

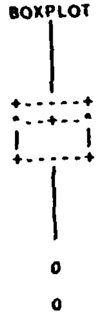
100% MAX	27.6797	99%	26.8197
75% Q3	6.7403	95%	20.3106
50% MED	0.800729	90%	13.9859
25% Q1	-7.28858	10%	-12.3887
0% MIN	-45.7898	5%	-17.7148
		1%	-42.7518
RANGE	73.4693		
Q3-Q1	14.0289		
MODE	-15.1471		

EXTREMES

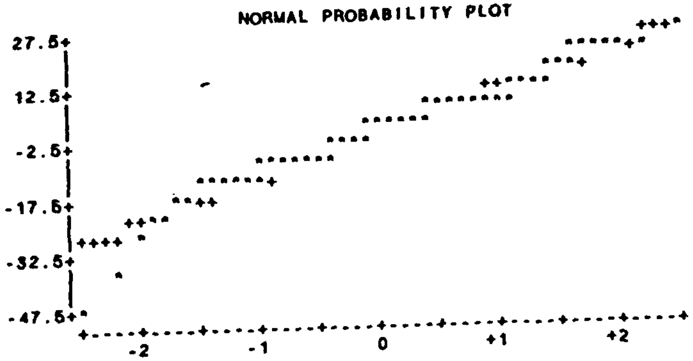
LOWEST	HIGHEST
-45.7898	20.5554
-35.3138	22.889
-27.2427	24.3045
-22.6848	24.714
-21.4973	27.6797

```
STEM LEAF                                #
   2 58                                  2
   2 01134                               5
   1 5569                                4
   1 0001122244                         10
   0 555555666666677778888888999        27
   0 11111122233334444                  17
  -0 444332222221111000                 18
  -0 999998877766666555555              21
  -1 4443222211110000                   16
  -1 55                                  2
  -2 310                                 3
  -2 7                                   1
  -3
  -3 5                                   1
  -4
  -4 6                                   1
     ----+----+----+----+----+--
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 25 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID   RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	6.661E-15	SUM	8.527E-13
STD DEV	12.73	VARIANCE	162.054
SKEWNESS	-0.316766	KURTOSIS	0.95486
USS	20580.9	CSS	20580.9
CV	99999	STD MEAN	1.12519
T:MEAN=0	5.920E-15	PROB>|T|	1
SGN RANK	92	PROB>|S|	0.82774
NUM ^= 0	128		
D:NORMAL	0.0527834	PROB>D	>.15

QUANTILES(DEF=4)

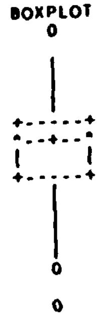
100% MAX	33.0698	99%	32.6662
75% Q3	7.22253	95%	21.4864
50% MED	0.140121	90%	15.9662
25% Q1	-7.70149	10%	-14.6577
0% MIN	-42.4272	5%	-20.7794
		1%	-40.1586
RANGE	75.497		
Q3-Q1	14.924		
MODE	7.16473		

EXTREMES

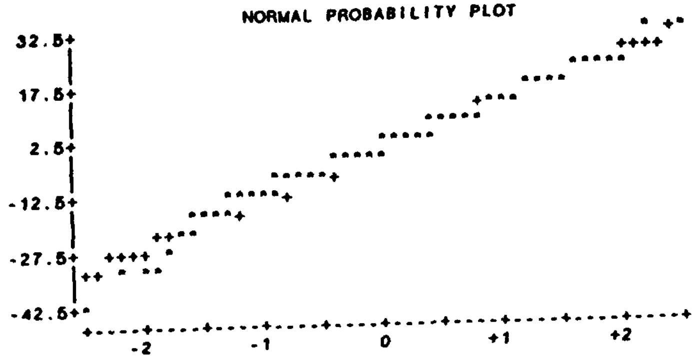
LOWEST	HIGHEST
-42.4272	22.6954
-34.6048	22.9453
-32.0663	23.6066
-30.6979	31.7472
-27.5053	33.0698

```
STEM LEAF                          #
   3 23                            2
   2
   2 112334                        6
   1 555666788                     9
   1 000111223                     9
   0 555555666777777788888        21
   0 12222333344444               14
  -0 4443322222111111100000       22
  -0 988888877666555555           18
  -1 44333222100000               14
  -1 766555                        6
  -2 11                            2
  -2 6                             1
  -3 21                            2
  -3 5                             1
  -4 2                             1
     ----+----+----+----+--
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 28 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID   RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	3.666E-14	SUM	4.718E-12
STD DEV	13.7865	VARIANCE	190.067
SKEWNESS	-0.610562	KURTOSIS	1.46596
USS	24138.5	CSS	24138.5
CV	99999	STD MEAN	1.21858
T:MEAN=0	3.025E-14	PROB>|T|	1
SGN RANK	198	PROB>|S|	0.641983
NUM ^= 0	128		
D:NORMAL	0.0842529	PROB>D	0.024

QUANTILES(DEF=4)

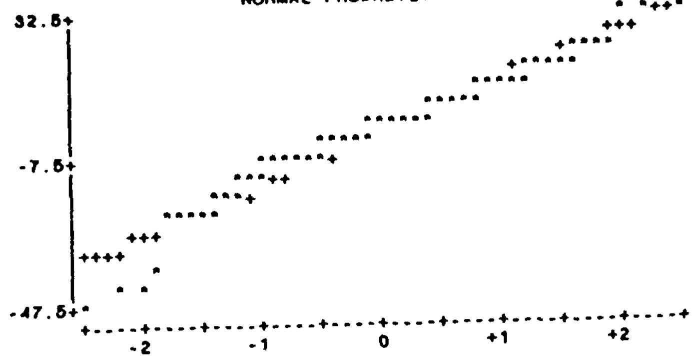
100% MAX	31.9055	99%	31.7554
75% Q3	7.61284	95%	20.3091
50% MED	0.46603	90%	16.9938
25% Q1	-6.62407	10%	-15.6216
0% MIN	-45.2017	5%	-22.8214
		1%	-44.2981
RANGE	77.1072		
Q3-Q1	14.2369		
MODE	-45.2017		

EXTREMES

LOWEST	HIGHEST
-45.2017	20.8784
-42.0859	24.9254
-40.9975	30.9265
-39.3615	31.388
-24.126	31.9055

```
STEM LEAF                          #       BOXPLOT
   3 112                           3          0
   2 5                             1          |
   2 0001                          4          |
   1 56778999                      8          |
   1 011222222334                 12       +-----+
   0 555555566666677788899        21       *--+--*
   0 1111112233334444             16       |     |
  -0 4444333322222111000000       21       +-----+
  -0 9999998877776666665555       22          |
  -1 43300                         5          |
  -1 66555                         5          |
  -2 4333220                       7          |
  -2
  -3
  -3 9                             1          0
  -4 21                            2          0
  -4 5                             1          0
     ----+----+----+----+--
MULTIPLY STEM.LEAF BY 10**+01
```

NORMAL PROBABILITY PLOT



DAY 27 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.910E-14	SUM	2.444E-12
STD DEV	18.4655	VARIANCE	340.978
SKEWNESS	-0.278792	KURTOSIS	0.754879
USS	43304	CSS	43304
CV	99999	STD MEAN	1.63214
T:MEAN=0	1.170E-14	PROB>|T|	1
SGN RANK	107	PROB>|S|	0.800057
NUM ^= 0	128		
D:NORMAL	0.0397184	PROB>D	>.15

QUANTILES(DEF=4)

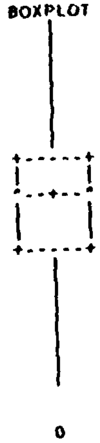
100% MAX	49.1891	99%	48.4528
75% Q3	13.2537	95%	27.6472
50% MED	0.439422	90%	22.4777
25% Q1	-12.0661	10%	-22.0683
0% MIN	-62.6177	5%	-33.51
		1%	-57.7642
RANGE	111.807		
Q3-Q1	25.3197		
MODE	-62.6177		

EXTREMES

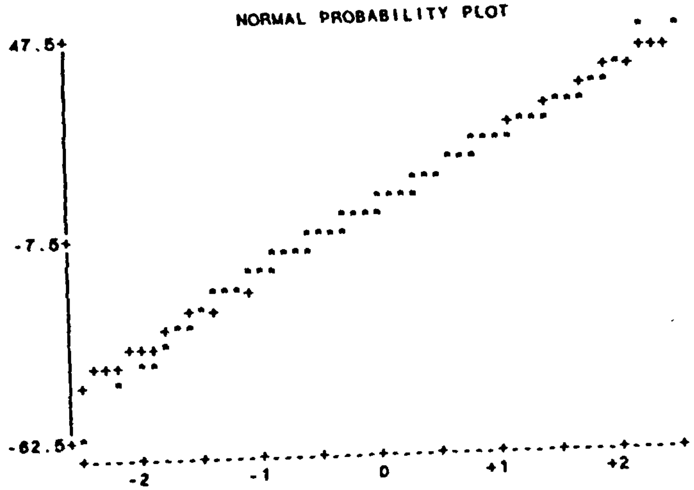
LOWEST	HIGHEST
-62.6177	31.1113
-45.8814	33.3052
-41.8719	37.1597
-40.5623	46.6501
-38.8808	49.1891

```
STEM LEAF                 #
   4 79                   2
   4
   3 7                    1
   3 13                   2
   2 5569                 4
   2 001222344            9
   1 55566677889         11
   1 0001333344          10
   0 5666677799          10
   0 112222333344444     15
  -0 444433332221000     15
  -0 9988776666555       13
  -1 4433332222100       13
  -1 98665                5
  -2 33221100             8
  -2 55                   2
  -3 20                   2
  -3 75                   2
  -4 21                   2
  -4 6                    1
  -5
  -5
  -6 3                    1
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 28 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.707E-14	SUM	2.185E-12
STD DEV	16.5342	VARIANCE	273.38
SKEWNESS	0.413422	KURTOSIS	0.571902
USS	34719.3	CSS	34719.3
CV	99999	STD MEAN	1.46143
T:MEAN=0	1.168E-14	PROB>|T|	1
SGN RANK	-164	PROB>|S|	0.897404
NUM ^= 0	128		
D:NORMAL	0.0429825	PROB>D	>.15

QUANTILES(DEF=4)

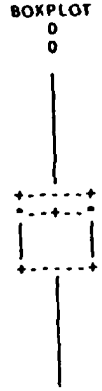
100% MAX	54.2213	99%	52.6992
75% Q3	9.59665	95%	27.939
50% MED	1.10751	90%	21.6579
25% Q1	-12.1345	10%	-20.3564
0% MIN	-41.9134	5%	-25.3577
		1%	-39.3051
RANGE	96.1347		
Q3-Q1	21.7313		
MODE	-41.9134		

EXTREMES

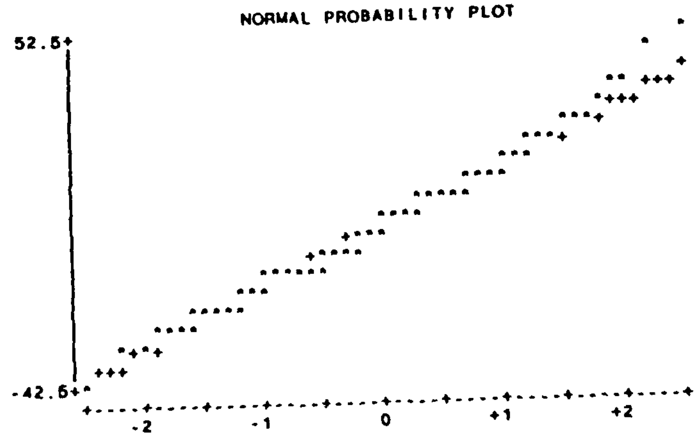
LOWEST	HIGHEST
-41.9134	33.366
-32.9193	35.1271
-31.0429	38.3865
-26.5486	48.9727
-26.3178	54.2213

```
STEM LEAF                     #
   5 4                        1
   4 9                        1
   4
   3 58                       2
   3 03                       2
   2 566                      3
   2 002234                   6
   1 567789                   6
   1 00111133334             11
   0 555666667777888999      18
   0 112222222334444         15
  -0 443222211                9
  -0 99998866666656          14
  -1 4444433211100000        16
  -1 877766555                9
  -2 44311000                 8
  -2 7665                     4
  -3 31                       2
  -3
  -4 2                        1
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 29 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	7.244E-15	SUM	9.273E-13
STD DEV	14.6841	VARIANCE	215.623
SKEWNESS	0.695573	KURTOSIS	1.80601
USS	27384.2	CSS	27384.2
CV	99999	STD MEAN	1.2979
T:MEAN=0	5.581E-15	PROB>|T|	1
SGN RANK	-177	PROB>|S|	0.674673
NUM ^= 0	128		
D:NORMAL	0.0636045	PROB>D	>.15

QUANTILES(DEF=4)

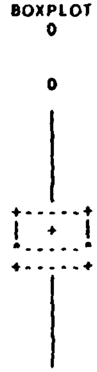
100% MAX	58.7839	99%	54.0759
75% Q3	8.89453	95%	23.451
50% MED	-1.21354	90%	17.8391
25% Q1	-8.05859	10%	-18.9411
0% MIN	-30.612	5%	-24.8862
		1%	-29.7858
RANGE	89.3958		
Q3-Q1	16.9531		
MODE	-1.38198		

EXTREMES

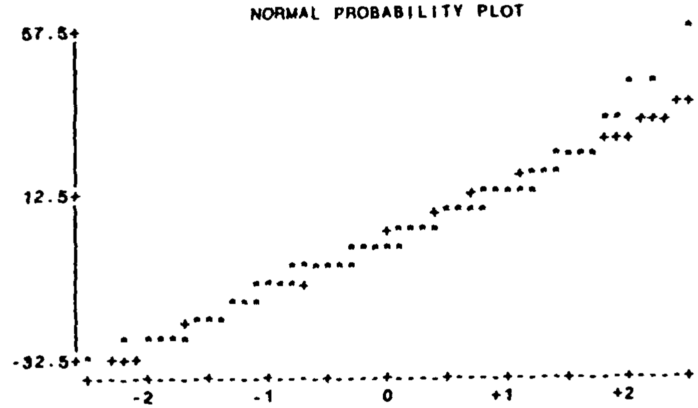
LOWEST	HIGHEST
-30.612	31.2474
-27.763	31.4089
-27.4401	40.4245
-26.987	42.5495
-26.5851	58.7839

```
STEM LEAF                          #
   5 9                             1
   5
   4
   4 03                            2
   3
   3 11                            2
   2
   2 011134                        6
   1 56789                         5
   1 000111112233                 12
   0 55555677889999999            17
   0 11112333444                  11
  -0 44444333322111111110000      23
  -0 988888877776666665555        21
  -1 42221110                      8
  -1 997766555                     9
  -2 43221                         5
  -2 87775                         5
  -3 1                             1
     ----+----+----+----+---
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 30 -- ANALYSIS OF RESIDUALS -- NO ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	4.885E-15	SUM	6.253E-13
STD DEV	15.6991	VARIANCE	246.462
SKEWNESS	0.401165	KURTOSIS	1.12765
USS	31300.6	CSS	31300.6
CV	99999	STD MEAN	1.38762
T:MEAN=0	3.520E-15	PROB>|T|	1
SGN RANK	-63	PROB>|S|	0.881842
NUM ^= 0	128		
D:NORMAL	0.0510371	PROB>D	>.15

QUANTILES(DEF=4)

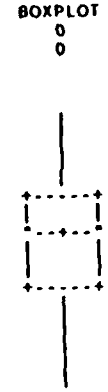
100% MAX	56.7422	99%	54.8391
75% Q3	10.0859	95%	25.6289
50% MED	0.328125	90%	19 1594
25% Q1	-10.6836	10%	-21.5125
0% MIN	-37.8203	5%	-26.9555
		1%	-36.10/5
RANGE	94.5625		
Q3-Q1	20.7695		
MODE	-37.8203		

EXTREMES

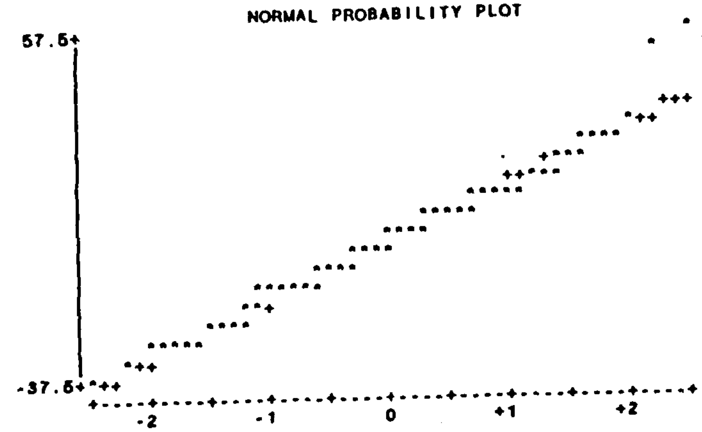
LOWEST	HIGHEST
-37.8203	26.6172
-31.9141	27.4141
-29.6641	34.2422
-28.5859	50.1797
-28.2109	56.7422

```
STEM LEAF                    #
   5 7                       1
   5 0                       1
   4
   4
   3
   3 4                       1
   2 55677                   5
   2 0012                    4
   1 56789                   5
   1 001111233333334 4      16
   0 5555566666678899       16
   0 11122333344            11
  -0 4443322222221110000    18
  -0 9888776555             10
  -1 3333332222211100000    19
  -1 8655                    4
  -2 4322111                 7
  -2 98775                   5
  -3 20                      2
  -3 8                       1
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



Appendix D: Regression Results for Attack Case

DAY 1 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	8	29484.62500	3685.57812	36.751	0.0001
ERROR	119	11933.84375	100.28440		
C TOTAL	127	41418.46875			

ROOT MSE	10.01421	R-SQUARE	0.7119
DEP MEAN	89.60938	ADJ R-SQ	0.6925
C.V.	11.1754		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	77.65625000	1.25177625	62.037	0.0001
B1	1	-10.17187500	2.34185892	-4.344	0.0001
B2	1	3.45312500	2.34185892	1.475	0.1430
B3	1	-13.35937500	2.34185892	-5.705	0.0001
B4	1	2.82812500	2.34185892	1.208	0.2296
B5	1	16.82812500	2.34185892	7.186	0.0001
B6	1	8.70312500	2.34185892	3.716	0.0003
B7	1	-2.60937500	2.34185892	-1.114	0.2674
D	1	23.90625000	1.77027894	13.504	0.0001

DAY 2 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	18	377449.12	20969.39559	77.159	0.0001
ERROR	109	29622.75446	271.76839		
C TOTAL	127	407071.88			

ROOT MSE	16.4854	R-SQUARE	0.9272
DEP MEAN	83.21875	ADJ R-SQ	0.9152
C.V.	19.80972		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	38.66741071	4.47422102	8.642	0.0001
B1	1	-6.53125000	3.85516975	-1.694	0.0931
B2	1	57.28125000	3.85516975	14.858	0.0001
B3	1	-29.40625000	3.85516975	-7.628	0.0001
B4	1	6.03125000	3.85516975	1.564	0.1206
B5	1	46.40625000	3.85516975	12.037	0.0001
B6	1	-16.59375000	3.85516975	-4.304	0.0001
B7	1	-35.40625000	3.85516975	-9.184	0.0001
B	1	-22.89285714	4.80122724	-4.768	0.0001
C	1	21.91964286	4.80122724	4.565	0.0001
D	1	81.15625000	2.91423441	27.848	0.0001
H	1	-11.56250000	5.04760206	-2.291	0.0239
J	1	26.75000000	5.04760206	5.300	0.0001
BE	1	8.28571429	4.92595522	1.682	0.0954
BH	1	35.50000000	5.82846881	6.091	0.0001
CE	1	9.66071429	4.92595522	1.961	0.0524
CJ	1	-47.25000000	5.82846881	-8.107	0.0001
EK	1	-7.48214286	3.81562850	-1.961	0.0524
HJ	1	-11.25000000	5.82846881	-1.930	0.0562

DAY 3 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	15	259266.71	17284.44708	27.815	0.0001
ERROR	112	69596.79375	621.39994		
C TOTAL	127	328863.50			

ROOT MSE	24.92789	R-SQUARE	0.7884
DEP MEAN	104.3125	ADJ R-SQ	0.7600
C.V.	23.89732		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	98.00312500	5.57404675	17.582	0.0001
B1	1	-9.75000000	5.82947763	-1.673	0.0972
B2	1	20.31250000	5.82947763	3.484	0.0007
B3	1	-23.62500000	5.82947763	-4.053	0.0001
B4	1	28.31250000	5.82947763	4.857	0.0001
B5	1	7.12500000	5.82947763	1.222	0.2242
B6	1	63.87500000	5.82947763	10.957	0.0001
B7	1	-34.37500000	5.82947763	-5.897	0.0001
B	1	-41.68750000	6.96755844	-5.983	0.0001
C	1	10.20000000	5.57404675	1.830	0.0699
D	1	44.65625000	4.40667088	10.134	0.0001
H	1	-33.56250000	6.23197373	-5.386	0.0001
BE	1	13.12500000	6.23197373	2.106	0.0374
BH	1	59.87500000	6.81334176	8.794	0.0001
CJ	1	-17.71250000	6.82678517	-2.595	0.0107
FJ	1	10.73750000	5.57404675	1.926	0.0566

DAY 4 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	73074.56202	4298.50365	10.497	0.0001
ERROR	110	45045.65673	409.50597		
C TOTAL	127	118120.22			

ROOT MSE	20.23625	R-SQUARE	0.6186
DEP MEAN	92.32813	ADJ R-SQ	0.5597
C.V.	21.91776		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	68.82860577	4.71147322	14.609	0.0001
B1	1	3.73437500	4.73232055	0.789	0.4317
B2	1	0.29687500	4.73232055	0.063	0.9501
B3	1	29.67187500	4.73232055	6.270	0.0001
B4	1	9.35937500	4.73232055	1.978	0.0505
B5	1	17.10937500	4.73232055	3.615	0.0005
B6	1	-12.82812500	4.73232055	-2.711	0.0078
B7	1	-12.89062500	4.73232055	-2.724	0.0075
D	1	18.96875000	3.57729808	5.303	0.0001
E	1	11.56490385	4.54666651	2.544	0.0124
J	1	10.00000000	5.05906346	1.977	0.0506
K	1	13.14375000	5.76821984	2.279	0.0246
BH	1	18.57500000	4.52496392	4.105	0.0001
CF	1	-11.89903846	4.43709218	-2.682	0.0085
EG	1	-11.81730769	5.61252699	-2.106	0.0375
FG	1	18.63461538	4.86059096	3.834	0.0002
HK	1	-13.16250000	5.54192636	-2.375	0.0193
JK	1	-13.68750000	7.15459617	-1.913	0.0583

DAY 5 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	106040.49	6237.67604	10.400	0.0001
ERROR	110	65974.12446	599.76477		
C TOTAL	127	172014.62			

ROOT MSE	24.4901	R-SQUARE	0.6165
DEP MEAN	102.0547	ADJ R-SQ	0.5572
C.V.	23.99703		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	71.75296336	5.55524446	12.916	0.0001
B1	1	7.13281250	5.72709662	1.245	0.2156
B2	1	-22.36718750	5.72709662	-3.906	0.0002
B3	1	53.25781250	5.72709662	9.299	0.0001
B4	1	4.82031250	5.72709662	0.842	0.4018
B5	1	-1.80468750	5.72709662	-0.315	0.7533
B6	1	2.69531250	5.72709662	0.471	0.6388
B7	1	-11.80468750	5.72709662	-2.061	0.0416
D	1	13.89062500	4.32927811	3.209	0.0017
E	1	14.41864224	5.51144422	2.616	0.0101
G	1	9.57812500	4.32927811	2.212	0.0290
J	1	11.56788793	5.68462066	2.035	0.0443
K	1	12.13038793	5.68462066	2.134	0.0351
BC	1	11.29956897	6.01603703	1.878	0.0630
BH	1	24.12607759	6.22718993	3.874	0.0002
CE	1	-12.24353448	6.82154479	-1.795	0.0754
HJ	1	-12.35452586	7.36811049	-1.677	0.0964
HK	1	-12.79202586	7.36811049	-1.736	0.0853

DAY 6 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	16	99847.14508929	6243.44656808	6.09	0.0001
ERROR	111	113693.28459821	1024.26382521		
C TOTAL	127	213540.42968750			

R-SQUARE	0.46757958
C(P)	-9.23606087

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	TYPE II SS	F	PROB>F
INTERCEP	1	138.62053571				
B1	1	-30.85156250	7.48427872	17404.68861607	16.99	0.0001
B2	1	9.71093750	7.48427872	1724.38504464	1.68	0.1971
B3	1	15.96093750	7.48427872	4658.31361607	4.55	0.0352
B4	1	11.33593750	7.48427872	2349.77790179	2.29	0.1327
B5	1	14.83593750	7.48427872	4024.77790179	3.93	0.0499
B6	1	-8.47656250	7.48427872	1313.86718750	1.28	0.2598
B7	1	-26.60156250	7.48427872	12939.76004464	12.63	0.0006
E	1	10.89062500	5.65758292	3795.38281250	3.71	0.0568
G	1	13.59895833	7.30390815	3550.68802083	3.47	0.0653
J	1	34.47842262	9.48303354	13539.79343851	13.22	0.0004
BH	1	24.98809524	7.80820625	10490.00238095	10.24	0.0018
BK	1	17.90476190	7.30820625	5385.75238095	5.26	0.0237
FG	1	18.02083333	9.23879423	3897.00520833	3.80	0.0536
FJ	1	-21.41666667	9.23879423	5504.08333333	5.37	0.0223
HJ	1	-24.77529762	8.90272488	7932.38327083	7.74	0.0063
JK	1	-22.23363095	8.90272488	6388.32077038	6.24	0.0140

Bounds on Condition Number: 2.809524, 452.7619

DAY 7 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	94239.35882	5543.49170	7.850	0.0001
ERROR	110	77682.25836	706.20235		
C TOTAL	127	171921.62			

ROOT MSE	26.57447	R-SQUARE	0.5482
DEP MEAN	148.5547	ADJ R-SQ	0.4783
C.V.	17.88866		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	121.05478	5.83197863	20.757	0.0001	INTERCEPT
B1	1	-26.74218750	6.21453465	-4.303	0.0001	
B2	1	5.32031250	6.21453465	0.856	0.3938	
B3	1	23.00781250	6.21453465	3.702	0.0003	
B4	1	8.50781250	6.21453465	1.369	0.1738	
B5	1	17.38281250	6.21453465	2.797	0.0061	
B6	1	-6.11718750	6.21453465	-0.984	0.3271	
B7	1	-37.92968750	6.21453465	-6.103	0.0001	
E	1	10.50091912	5.97491149	1.758	0.0816	Personnel
H	1	25.84687500	7.57488883	3.412	0.0009	Spare Parts
K	1	13.84375000	6.64361700	2.084	0.0395	FUEL
AB	1	16.11764706	5.80987453	2.774	0.0065	ATTRITION & FILLERS
BG	1	20.30330882	6.24059152	3.253	0.0015	Fillers & Spt Equip
CJ	1	10.51250000	5.94223169	1.769	0.0796	ABDR & MISSILES
EF	1	-14.40808824	7.38396746	-1.951	0.0536	PERSONNEL & AIS
FG	1	13.00367647	6.44525520	2.018	0.0461	AIS & SPT EQUIP
HJ	1	-14.50625000	7.27771778	-1.993	0.0487	SPARES & MISSILES
HK	1	-21.40625000	9.39549326	-2.278	0.0246	SPARES & FUEL

DAY 8 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	15	84847.43642	5656.49578	6.604	0.0001
ERROR	112	95926.43077	856.48599		
C TOTAL	127	180773.87			

ROOT MSE	29.26578	R-SQUARE	0.4694
DEP MEAN	145.6797	ADJ R-SQ	0.3983
C.V.	20.08913		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	115.82103	5.74845299	20.148	0.0001
B1	1	-22.17968750	6.84390806	-3.241	0.0016
B2	1	-0.05468750	6.84390806	-0.008	0.9936
B3	1	14.50781250	6.84390806	2.120	0.0362
B4	1	5.75781250	6.84390806	0.841	0.4020
B5	1	14.50781250	6.84390806	2.120	0.0362
B6	1	-7.80468750	6.84390806	-1.140	0.2566
B7	1	-24.92968750	6.84390806	-3.643	0.0004
A	1	13.73125000	6.54402777	2.098	0.0381
B	1	30.67187500	5.17350821	5.929	0.0001
E	1	18.90985577	6.57541417	2.876	0.0048
AK	1	-18.80625000	8.01476445	-2.346	0.0207
CE	1	-18.22596154	8.11686748	-2.245	0.0287
CJ	1	19.26442308	7.02941343	2.741	0.0071
DJ	1	-11.03605769	6.41694717	-1.720	0.0882
GK	1	21.61250000	6.54402777	3.303	0.0013

DAY 9 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	16	87761.39063	5485.08691	8.092	0.0001
ERROR	111	75240.48437	677.84220		
C TOTAL	127	163001.88			

ROOT MSE	26.0354	R-SQUARE	0.5384
DEP MEAN	137.2813	ADJ R-SQ	0.4719
C.V.	18.96501		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	92.06250000	6.90367871	13.335	0.0001
B1	1	-21.53125000	6.08847234	-3.536	0.0006
B2	1	-0.53125000	6.08847234	-0.087	0.9306
B3	1	17.53125000	6.08847234	2.879	0.0048
B4	1	11.46875000	6.08847234	1.884	0.0622
B5	1	16.15625000	6.08847234	2.654	0.0091
B6	1	-11.65625000	6.08847234	-1.914	0.0581
B7	1	-30.96875000	6.08847234	-5.086	0.0001
A	1	29.06250000	9.20490495	3.157	0.0021
B	1	24.31250000	4.60245248	5.283	0.0001
E	1	15.48437500	7.27711632	2.128	0.0356
G	1	25.96875000	6.50885071	3.990	0.0001
K	1	13.21875000	6.50885071	2.031	0.0447
AE	1	-16.00000000	9.20490495	-1.738	0.0849
AG	1	-15.56250000	9.20490495	-1.691	0.0937
AK	1	-15.75000000	9.20490495	-1.711	0.0899
EH	1	12.09375000	6.50885071	1.858	0.0658

DAY 10 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	16	91900.53340	5743.78334	7.706	0.0001
ERROR	111	82736.96660	745.37808		
C TOTAL	127	174637.50			

ROOT MSE	27.30161	R-SQUARE	0.5262
DEP MEAN	132.3125	ADJ R-SQ	0.4579
C.V.	20.63419		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	107.62929	5.44923983	19.751	0.0001
B1	1	-20.00000000	6.38458014	-3.133	0.0022
B2	1	2.43750000	6.38458014	0.382	0.7034
B3	1	21.50000000	6.38458014	3.367	0.0010
B4	1	4.31250000	6.38458014	0.675	0.5008
B5	1	14.31250000	6.38458014	2.242	0.0270
B6	1	-6.00000000	6.38458014	-0.940	0.3494
B7	1	-32.12500000	6.38458014	-5.032	0.0001
E	1	9.12600000	4.82628894	1.891	0.0613
G	1	11.14599237	6.25444836	1.782	0.0775
K	1	10.91269084	6.13967609	1.777	0.0782
AB	1	11.16650763	6.25444836	1.785	0.0769
BG	1	17.[illegible]01527	7.95614464	2.257	0.0260
BJ	1	21.91746183	6.79930221	3.223	0.0017
FH	1	19.33826336	6.64054174	2.912	0.0043
FJ	1	-20.25190840	6.53255826	-3.100	0.0025
HK	1	-13.76288168	7.59014680	-1.813	0.0725

DAY 11 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	106954.19	5347.70938	9.083	0.0001
ERROR	107	62997.81250	588.76460		
C TOTAL	127	169952.00			

ROOT MSE	24.26447	R-SQUARE	0.6293
DEP MEAN	127.125	ADJ R-SQ	0.5600
C.V.	19.0871		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	71.96875000	6.71396231	10.719	0.0001
B1	1	-16.25000000	5.67433381	-2.864	0.0050
B2	1	-1.18750000	5.67433381	-0.209	0.8346
B3	1	14.37500000	5.67433381	2.533	0.0127
B4	1	1.62500000	5.67433381	0.286	0.7751
B5	1	17.12500000	5.67433381	3.018	0.0032
B6	1	-9.06250000	5.67433381	-1.597	0.1132
B7	1	-30.18750000	5.67433381	-5.320	0.0001
A	1	21.84375000	7.42944692	2.940	0.0040
B	1	31.53125000	4.28939318	7.351	0.0001
G	1	27.50000000	5.42570089	5.068	0.0001
H	1	21.65625000	7.42944692	2.915	0.0043
K	1	30.18750000	8.68535922	3.476	0.0007
AH	1	-14.43750000	8.57878636	-1.683	0.0953
AK	1	-21.75000000	8.57878636	-2.535	0.0127
CJ	1	18.75000000	5.42570089	3.456	0.0008
DE	1	12.00000000	5.42570089	2.212	0.0291
DG	1	-16.12500000	6.64509934	-2.427	0.0169
FK	1	10.93750000	6.06811801	1.803	0.0742
HK	1	-15.56250000	8.57878636	-1.814	0.0725
JK	1	-18.62500000	6.64509934	-2.803	0.0060

DAY 12 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	21	110390.92	5256.71032	10.254	0.0001
ERROR	106	54339.95833	512.64112		
C TOTAL	127	164730.88			

ROOT MSE	22.64158	R-SQUARE	0.6701
DEP MEAN	121.1563	ADJ R-SQ	0.6048
C.V.	18.68792		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	78.87500000	5.66039484	13.935	0.0001	INTERCEPT
B1	1	-16.90625000	5.29481454	-3.193	0.0019	
B2	1	-2.90625000	5.29481454	-0.549	0.5842	
B3	1	17.84375000	5.29481454	3.370	0.0010	
B4	1	2.03125000	5.29481454	0.384	0.7020	
B5	1	16.15625000	5.29481454	3.051	0.0029	
B6	1	-8.71875000	5.29481454	-1.647	0.1026	
B7	1	-33.09375000	5.29481454	-6.250	0.0001	
A	1	14.34375000	5.66039484	2.534	0.0127	Attrition
B	1	27.78541667	5.98147790	4.645	0.0001	Filler Aircraft
E	1	15.57708333	5.26954082	2.956	0.0038	Personnel
G	1	17.71875000	4.00250358	4.427	0.0001	Support Equip
K	1	17.23125000	8.20269142	2.101	0.0380	FUEL
AK	1	-20.00000000	8.00500715	-2.498	0.0140	Attrition & Fuel
BD	1	-11.56250000	5.66039484	-2.043	0.0436	Fillers & Recovery
BH	1	19.99166667	6.85507858	2.916	0.0043	Fillers & Spares
CJ	1	12.28750000	5.06281108	2.427	0.0169	ABDR & MISSILES
EF	1	-17.71666667	6.85507858	-2.584	0.0111	PERSONNEL & AIS
FH	1	11.71250000	6.20065188	1.889	0.0616	AIS & Spares
FK	1	15.03333333	6.85507858	2.193	0.0305	AIS & Fuel
HK	1	-14.32083333	6.85507858	-2.089	0.0391	SPARES & FUEL
JK	1	-11.61250000	6.20065188	-1.873	0.0639	MISSILES & FUEL

DAY 13 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	15	100034.55	6668.96979	12.164	0.0001
ERROR	112	61403.44531	548.24505		
C TOTAL	127	161437.99			

ROOT MSE	23.41463	R-SQUARE	0.6196
DEP MEAN	116.4922	ADJ R-SQ	0.5687
C.V.	20.09975		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	80.76562500	5.23567115	15.426	0.0001
B1	1	-18.80468750	5.47559595	-3.434	0.0008
B2	1	3.13281250	5.47559595	0.572	0.5684
B3	1	15.63281250	5.47559595	2.855	0.0051
B4	1	6.25781250	5.47559595	1.143	0.2555
B5	1	13.00781250	5.47559595	2.376	0.0192
B6	1	-4.17968750	5.47559595	-0.763	0.4469
B7	1	-36.67968750	5.47559595	-6.699	0.0001
A	1	10.43750000	5.85365830	1.783	0.0773
B	1	26.76562500	5.06941679	5.280	0.0001
G	1	19.45312500	4.13916148	4.700	0.0001
K	1	15.95312500	6.67419734	2.390	0.0185
AK	1	-15.34375000	8.27832295	-1.853	0.0664
BH	1	13.75000000	5.85365830	2.349	0.0206
EJ	1	12.87500000	5.23567115	2.459	0.0155
JK	1	-13.59375000	6.41236139	-2.120	0.0362

DAY 14 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	19	103886.22	5467.69597	9.817	0.0001
ERROR	108	60149.27654	556.93775		
C TOTAL	127	164035.50			

ROOT MSE	23.59953	R-SQUARE	0.6333
DEP MEAN	110.3125	ADJ R-SQ	0.5688
C.V.	21.39334		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	77.40688158	5.33313207	14.515	0.0001
B1	1	-18.12500000	5.51883438	-3.284	0.0014
B2	1	-0.50000000	5.51883438	-0.091	0.9280
B3	1	17.00000000	5.51883438	3.080	0.0026
B4	1	10.25000000	5.51883438	1.857	0.0660
B5	1	16.18750000	5.51883438	2.933	0.0041
B6	1	-10.43750000	5.51883438	-1.891	0.0613
B7	1	-37.31250000	5.51883438	-6.761	0.0001
B	1	21.32236842	5.41410315	3.938	0.0001
C	1	19.46546053	6.76782894	2.876	0.0048
G	1	24.78125000	5.89988213	4.200	0.0001
AH	1	-10.38486842	5.41410315	-1.918	0.0577
BH	1	13.73026316	6.90185440	1.989	0.0492
CD	1	-13.74342105	6.63089507	-2.073	0.0406
CG	1	-15.37500000	8.34369332	-1.843	0.0681
DH	1	14.29934211	6.05315134	2.362	0.0200
EF	1	-9.86666667	5.69982764	-1.731	0.0863
EJ	1	18.80000000	5.69982764	3.298	0.0013
FK	1	18.05000000	5.69982764	3.167	0.0020
JK	1	-15.03333333	5.69982764	-2.638	0.0096

DAY 15 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	102988.97	6058.17483	10.633	0.0001
ERROR	110	62670.90625	569.73551		
C TOTAL	127	165659.88			

ROOT MSE	23.86913	R-SQUARE	0.6217
DEP MEAN	106.7813	ADJ R-SQ	0.5632
C.V.	22.3533		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	73.20572917	5.19168885	14.101	0.0001
B1	1	-19.84375000	5.58188237	-3.555	0.0006
B2	1	2.40625000	5.58188237	0.431	0.6673
B3	1	12.03125000	5.58188237	2.155	0.0333
B4	1	12.78125000	5.58188237	2.290	0.0239
B5	1	19.21875000	5.58188237	3.443	0.0008
B6	1	-10.78125000	5.58188237	-1.931	0.0560
B7	1	-34.03125000	5.58188237	-6.097	0.0001
A	1	19.18229167	6.96183047	2.755	0.0069
B	1	23.04687500	5.16781889	4.460	0.0001
C	1	15.68750000	5.96728326	2.629	0.0098
AC	1	-14.31250000	8.43901291	-1.696	0.0927
AK	1	-22.67708333	7.17178192	-3.162	0.0020
BH	1	16.21875000	5.96728326	2.718	0.0076
EJ	1	15.13541667	5.26264917	2.876	0.0048
FK	1	13.91145833	5.53740451	2.512	0.0134
GK	1	23.09895833	5.53740451	4.171	0.0001
JK	1	-12.90625000	5.96728326	-2.163	0.0327

DAY 16 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	15	85220.35417	5681.35694	11.528	0.0001
ERROR	112	55196.45052	492.82545		
C TOTAL	127	140416.80			

ROOT MSE	22.19967	R-SQUARE	0.6069
DEP MEAN	100.0391	ADJ R-SQ	0.5543
C.V.	22.191		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	74.71875000	3.89777840	19.170	0.0001
B1	1	-22.10156250	5.19147299	-4.257	0.0001
B2	1	0.02343750	5.19147299	0.005	0.9964
B3	1	11.02343750	5.19147299	2.123	0.0359
B4	1	10.89843750	5.19147299	2.099	0.0380
B5	1	18.52343750	5.19147299	3.568	0.0005
B6	1	-7.91406250	5.19147299	-1.524	0.1302
B7	1	-30.91406250	5.19147299	-5.955	0.0001
B	1	18.85937500	4.80637005	3.924	0.0002
G	1	15.39062500	3.92436471	3.922	0.0002
BH	1	16.00000000	5.54991806	2.883	0.0047
CJ	1	10.59375000	4.99742561	2.120	0.0362
EF	1	-9.95833333	5.37207111	-1.854	0.0664
EJ	1	13.88541667	5.52486189	2.513	0.0134
FK	1	18.58333333	5.37207111	3.459	0.0008
JK	1	-16.32291667	5.52486189	-2.954	0.0038

DAY 17 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	94207.41491	4710.37075	9.355	0.0001
ERROR	107	53874.76478	503.50247		
C TOTAL	127	148082.18			

ROOT MSE	22.43886	R-SQUARE	0.6362
DEP MEAN	95.85156	ADJ R-SQ	0.5682
C.V.	23.41001		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	77.31882096	3.81640049	20.260	0.0001	INTERCEPT
B1	1	-17.35156250	5.24740808	-3.307	0.0013	
B2	1	1.14843750	5.24740808	0.219	0.8272	
B3	1	10.02343750	5.24740808	1.910	0.0588	
B4	1	8.52343750	5.24740808	1.624	0.1073	
B5	1	18.96093750	5.24740808	3.613	0.0005	
B6	1	-5.53906250	5.24740808	-1.056	0.2935	
B7	1	-35.60156250	5.24740808	-6.785	0.0001	
G	1	23.16418047	7.10336598	3.261	0.0015	Support Equip
AK	1	-14.97159224	5.35059410	-2.798	0.0061	Attrition & Fuel
BH	1	20.65509042	5.64147258	3.661	0.0004	Fillers & Spares
BK	1	22.82566255	5.84983289	3.902	0.0002	FILLERS & FUEL
CJ	1	10.26810693	5.22520478	1.965	0.0520	ABDR & MISSILES
EG	1	-14.88707129	6.33300260	-2.351	0.0206	Personnel & Spt Equip
EJ	1	13.46164257	5.87810080	2.290	0.0240	Personnel & Missiles
FG	1	-16.18560517	6.37936468	-2.537	0.0126	AIS & SPT EQUIP
FK	1	20.43371035	6.07532438	3.363	0.0011	AIS & Fuel
GK	1	12.02556652	7.18175602	1.674	0.0970	SPT EQUIP & FUEL
HJ	1	10.32850726	5.99598474	1.723	0.0879	SPARES & MISSILES
HK	1	-14.27589108	5.98860809	-2.384	0.0189	SPARES & FUEL
JK	1	-21.87572062	6.29976132	-3.472	0.0007	MISSILES & FUEL

DAY 16 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	82017.29553	4100.86478	8.644	0.0001
ERROR	107	50760.57947	474.39794		
C TOTAL	127	132777.88			

ROOT MSE	21.78066	R-SQUARE	0.6177
DEP MEAN	89.03125	ADJ R-SQ	0.5462
C.V.	24.46408		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	66.51895826	4.14296914	16.056	0.0001
B1	1	-19.90625000	5.09348970	-3.908	0.0002
B2	1	0.53125000	5.09348970	0.104	0.9171
B3	1	6.65625000	5.09348970	1.307	0.1941
B4	1	4.65625000	5.09348970	0.914	0.3627
B5	1	14.96875000	5.09348970	2.939	0.0040
B6	1	-6.09375000	5.09348970	-1.196	0.2342
B7	1	-26.28125000	5.09348970	-5.160	0.0001
B	1	16.20075686	5.11669616	3.166	0.0020
C	1	13.15183038	4.93180993	2.667	0.0088
BH	1	12.34848228	6.73962736	1.832	0.0697
CD	1	-16.49116076	6.16370459	-2.676	0.0086
DH	1	10.41982152	5.77629055	1.804	0.0741
EF	1	-17.16520053	5.52082280	-3.109	0.0024
EJ	1	17.83313549	5.50714496	3.238	0.0016
FH	1	12.60121672	5.78411927	2.179	0.0316
FK	1	12.06124936	5.81532878	2.074	0.0405
GJ	1	10.23120867	5.30817100	1.927	0.0566
GK	1	20.41385313	5.44008857	3.752	0.0003
HK	1	-16.84300280	5.96892904	-2.822	0.0057
JK	1	-14.06541462	5.71503441	-2.461	0.0154

DAY 19 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	19	82509.73349	4342.61755	8.705	0.0001
ERROR	108	53880.19619	498.89071		
C TOTAL	127	136389.93			

ROOT MSE	22.33588	R-SQUARE	0.6050
DEP MEAN	86.52344	ADJ R-SQ	0.5355
C.V.	25.81481		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	61.40722096	4.53935610	13.528	0.0001
B1	1	-19.21093750	5.22332131	-3.678	0.0004
B2	1	-2.08593750	5.22332131	-0.399	0.6904
B3	1	10.28906250	5.22332131	1.970	0.0514
B4	1	7.91406250	5.22332131	1.515	0.1327
B5	1	17.16406250	5.22332131	3.286	0.0014
B6	1	-5.64843750	5.22332131	-1.081	0.2819
B7	1	-29.08593750	5.22332131	-5.568	0.0001
B	1	15.14821343	5.18249949	2.923	0.0042
C	1	11.52449809	5.04551856	2.284	0.0243
G	1	11.36209369	6.32017745	1.798	0.0750
BH	1	19.42232314	6.71355836	2.893	0.0046
CE	1	-15.83024618	6.28233174	-2.520	0.0132
EJ	1	17.22289235	5.75743796	2.991	0.0034
FG	1	-12.04415631	6.32017745	-1.906	0 0594
FK	1	18.90081262	5.92080194	3.192	0.0018
GK	1	13.28871893	6.90616363	1.924	0.0570
HJ	1	13.97556166	5.82947305	2.397	0.0182
HK	1	-12.88270793	6.01074332	-2.143	0.0343
JK	1	-17.65804254	5.93086279	-2.977	0.0036

DAY 20 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	23	82173.13738	3572.74510	9.120	0.0001
ERROR	104	40741.08137	391.74117		
C TOTAL	127	122914.22			

ROOT MSE	19.79245	R-SQUARE	0.6685
DEP MEAN	79.17188	ADJ R-SQ	0.5952
C.V.	24.99935		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	59.11528697	3.94390931	14.989	0.0001
B1	1	-20.92187500	4.62853595	-4.520	0.0001
B2	1	-0.92187500	4.62853595	-0.199	0.8425
B3	1	11.07812500	4.62853595	2.393	0.0185
B4	1	7.57812500	4.62853595	1.637	0.1046
B5	1	14.95312500	4.62853595	3.231	0.0017
B6	1	-1.73437500	4.62853595	-0.375	0.7086
B7	1	-27.92187500	4.62853595	-6.033	0.0001
A	1	9.05252815	4.74057186	1.910	0.0589
G	1	14.65675773	7.13342898	2.055	0.0424
AK	1	-17.48005230	6.39722130	-2.732	0.0074
BH	1	18.93075339	4.98924066	3.794	0.0002
BK	1	21.16959715	5.19890934	4.072	0.0001
CE	1	-12.85195026	5.20624134	-2.469	0.0152
CG	1	11.33444154	5.94480423	1.907	0.0593
CJ	1	9.93306718	5.17755274	1.918	0.0578
EG	1	-11.49889179	5.94480423	-1.934	0.0558
EJ	1	19.97473385	5.17755274	3.858	0.0002
FG	1	-14.54401291	5.95335351	-2.443	0.0163
FH	1	10.23709103	5.26556474	1.944	0.0546
FK	1	16.22593479	5.56150842	2.918	0.0043
GK	1	13.83244770	6.39722130	2.162	0.0329
HK	1	-12.76144836	5.33240888	-2.393	0.0185
JK	1	-19.69392686	5.58302304	-3.527	0.0006

DAY 21 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	80473.77152	4023.68858	11.739	0.0001
ERROR	107	36674.15817	342.74914		
C TOTAL	127	117147.93			

ROOT MSE	18.51349	R-SQUARE	0.6869
DEP MEAN	74.47656	ADJ R-SQ	0.6284
C.V.	24.85814		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	55.41579338	3.11981991	17.762	0.0001
B1	1	-20.47656250	4.32944496	-4.730	0.0001
B2	1	1.33593750	4.32944496	0.309	0.7582
B3	1	11.39843750	4.32944496	2.633	0.0097
B4	1	9.02343750	4.32944496	2.084	0.0395
B5	1	12.71093750	4.32944496	2.936	0.0041
B6	1	-4.53906250	4.32944496	-1.048	0.2968
B7	1	-29.35156250	4.32944496	-6.780	0.0001
B	1	21.21256157	5.02758114	4.219	0.0001
AK	1	-12.98171743	4.32175361	-3.004	0.0033
BE	1	-14.96633745	5.56575773	-2.689	0.0083
BH	1	13.82246431	5.20757167	2.654	0.0092
CG	1	13.23964618	4.37838412	3.024	0.0031
EG	1	-9.54954513	5.07284428	-1.882	0.0625
EJ	1	17.41972004	4.90080972	3.554	0.0006
FG	1	-10.70685062	5.01031329	-2.137	0.0349
FH	1	10.41757137	4.77367002	2.182	0.0313
FK	1	13.10042220	4.92010501	2.663	0.0089
GJ	1	9.08409982	4.93583597	1.840	0.0685
GK	1	21.67210746	5.02576190	4.312	0.0001
JK	1	-16.73362738	4.98031012	-3.360	0.0011

DAY 22 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	23	64030.57572	2783.93807	9.303	0.0001
ERROR	104	31121.42428	299.24446		
C TOTAL	127	95152.00000			

ROOT MSE	17.29868	R-SQUARE	0.6729
DEP MEAN	69.625	ADJ R-SQ	0.6006
C.V.	24.84551		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	51.38956822	3.37087560	15.245	0.0001	INTERCEPT
B1	1	-18.00000000	4.04535927	-4.450	0.0001	
B2	1	-1.56250000	4.04535927	-0.386	0.7001	
B3	1	11.12500000	4.04535927	2.750	0.0070	
B4	1	10.50000000	4.04535927	2.596	0.0108	
B5	1	8.31250000	4.04535927	2.055	0.0424	
B6	1	-3.31250000	4.04535927	-0.819	0.4148	
B7	1	-24.81250000	4.04535927	-6.134	0.0001	
B	1	11.13680698	5.57710420	1.997	0.0485	Filler Aircraft
G	1	12.17915811	6.54056011	1.862	0.0654	Support Equip
AG	1	8.66529774	4.92269887	1.760	0.0813	Attrition & Spt Equip
AK	1	-14.95559548	4.70326915	-3.180	0.0019	Attrition & Fuel
BE	1	-10.22689938	5.21072673	-1.963	0.0524	Fillers & Personnel
BH	1	13.44917864	5.21318288	2.580	0.0113	Fillers & Spares
BK	1	10.25410678	5.57394721	1.840	0.0687	FILLERS & FUEL
CG	1	9.50000000	4.32467097	2.197	0.0303	ABDR & Spt Equip
EG	1	-12.85189938	5.21072673	-2.466	0.0153	Personnel & Spt Equip
EJ	1	18.05569815	4.46449427	4.044	0.0001	Personnel & Missiles
FG	1	-12.55082136	5.21318288	-2.408	0.0178	AIS & SPT EQUIP
FH	1	11.14835729	4.62919729	2.408	0.0178	AIS & Spares
FK	1	11.32828542	4.83479818	2.343	0.0210	AIS & Fuel
GK	1	13.75410678	5.57394721	2.468	0.0152	SPT EQUIP & FUEL
HK	1	-8.29871458	4.83479818	-1.716	0.0891	SPARES & FUEL
JK	1	-10.96326569	4.60841049	-2.379	0.0192	MISSILES & FUEL

DEP VARIABLE: SORTIES

DAY 23 -- REDUCED MODEL WITH ATTACK

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	18	57678.40912	3204.35606	8.731	0.0001
ERROR	109	40004.06307	367.00994		
C TOTAL	127	97682.49219			

ROOT MSE	19.1575	R-SQUARE	0.5905
DEP MEAN	65.74219	ADJ R-SQ	0.5228
C.V.	29.14035		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	47.98058000	3.16881553	15.141	0.0001
B1	1	-21.05468750	4.48005088	-4.700	0.0001
B2	1	-0.55468750	4.48005088	-0.124	0.9017
B3	1	10.69531250	4.48005088	2.387	0.0187
B4	1	7.32031250	4.48005088	1.634	0.1051
B5	1	12.57031250	4.48005088	2.806	0.0059
B6	1	-4.05468750	4.48005088	-0.905	0.3674
B7	1	-22.86718750	4.48005088	-5.104	0.0001
B	1	18.21241500	5.19694730	3.504	0.0007
BE	1	-12.58069000	5.33803817	-2.357	0.0202
BH	1	14.43711000	5.74852804	2.511	0.0135
CG	1	11.76317000	4.38367885	2.683	0.0084
EJ	1	13.53638000	4.71445880	2.871	0.0049
FG	1	-10.54533000	4.93505617	-2.137	0.0348
FH	1	12.52169000	5.05554863	2.477	0.0148
FK	1	8.47031000	4.90821070	1.726	0.0872
GK	1	18.16207000	5.02350507	3.615	0.0005
HK	1	-12.02091000	5.15618074	-2.331	0.0216
JK	1	-9.12220000	4.92165174	-1.853	0.0665

DAY 24 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	65432.07032	3271.60352	10.683	0.0001
ERROR	107	32767.39843	306.23737		
C TOTAL	127	98199.46875			

ROOT MSE	17.49964	R-SQUARE	0.6663
DEP MEAN	62.14063	ADJ R-SQ	0.6039
C.V.	28.16135		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	51.78685189	3.64921974	14.192	0.0001
B1	1	-18.70312500	4.09235337	-4.570	0.0001
B2	1	-6.20312500	4.09235337	-1.516	0.1325
B3	1	17.10937500	4.09235337	4.181	0.0001
B4	1	8.67187500	4.09235337	2.119	0.0364
B5	1	10.04687500	4.09235337	2.455	0.0157
B6	1	-4.32812500	4.09235337	-1.058	0.2926
B7	1	-23.51562500	4.09235337	-5.746	0.0001
G	1	13.34338696	5.71752157	2.334	0.0215
K	1	-25.00597721	6.91556354	-3.616	0.0005
BH	1	21.52439024	4.53214202	4.749	0.0001
BK	1	16.80030488	4.92695782	3.410	0.0009
CE	1	-7.49342105	4.46856272	-1.689	0.0980
CK	1	11.80921053	4.91697411	2.402	0.0180
EG	1	-9.80263158	5.11774891	-1.915	0.0581
EJ	1	13.78618421	4.01469255	3.434	0.0008
FG	1	-10.88414634	5.29240167	-2.057	0.0422
FH	1	9.65243902	4.73366796	2.039	0.0439
FK	1	13.42835366	5.29240167	2.537	0.0126
GK	1	16.00000000	6.18705674	2.586	0.0111
HK	1	-10.08841463	5.20344740	-1.939	0.0552

DAY 25 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	20	62895.03845	3144.75192	10.705	0.0001
ERROR	107	31433.76623	293.77352		
C TOTAL	127	94328.80469			

ROOT MSE	17.13982	R-SQUARE	0.6668
DEP MEAN	58.96094	ADJ R-SQ	0.6045
C.V.	29.06979		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	38.14653395	3.83592315	9.945	0.0001
B1	1	-17.33593750	4.00820897	-4.325	0.0001
B2	1	-4.14843750	4.00820897	-1.035	0.3030
B3	1	11.28906250	4.00820897	2.816	0.0058
B4	1	11.60156250	4.00820897	2.894	0.0046
B5	1	10.97656250	4.00820897	2.739	0.0072
B6	1	-4.27343750	4.00820897	-1.066	0.2887
B7	1	-24.71093750	4.00820897	-6.165	0.0001
B	1	11.09375000	4.28495563	2.589	0.0110
C	1	11.68099619	3.85863456	3.027	0.0031
H	1	9.61984454	5.06726968	1.898	0.0603
AG	1	8.45420897	4.28857927	1.971	0.0513
AK	1	-10.23757403	4.42758868	-2.312	0.0227
BH	1	17.59375000	6.05984237	2.903	0.0045
CE	1	-13.76824239	4.77855136	-2.881	0.0048
EJ	1	18.34898477	4.23022854	4.338	0.0001
FG	1	-8.83745770	4.28857927	-2.061	0.0418
FK	1	18.59575931	4.42758868	4.200	0.0001
GK	1	16.61865482	4.43459981	3.747	0.0003
HK	1	-16.30216909	5.40976052	-3.013	0.0032
JK	1	-11.99746193	4.47643669	-2.680	0.0085

DAY 28 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	17	54344.55368	3196.73845	10.763	0.0001
ERROR	110	32672.32132	297.02110		
C TOTAL	127	87016.87500			

ROOT MSE	17.2343	R-SQUARE	0.6245
DEP MEAN	55.59375	ADJ R-SQ	0.5665
C.V.	31.00043		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	39.07261253	3.16211047	12.356	0.0001
B1	1	-19.65625000	4.03030291	-4.877	0.0001
B2	1	-0.96875000	4.03030291	-0.240	0.8105
B3	1	12.53125000	4.03030291	3.109	0.0024
B4	1	9.71875000	4.03030291	2.411	0.0175
B5	1	12.03125000	4.03030291	2.985	0.0035
B6	1	-2.53125000	4.03030291	-0.628	0.5313
B7	1	-21.96875000	4.03030291	-5.451	0.0001
C	1	10.96570864	4.00148203	2.740	0.0072
G	1	9.15100365	4.72841243	1.935	0.0555
BH	1	28.61161800	3.80178664	7.526	0.0001
CE	1	-12.18141727	5.18842903	-2.348	0.0207
EG	1	-9.24391727	5.18842903	-1.782	0.0776
EJ	1	19.48175182	4.41727690	4.410	0.0001
FK	1	12.53345499	4.00993885	3.126	0.0023
GK	1	13.12940998	5.21447989	2.518	0.0132
HK	1	-11.08485401	4.32427118	-2.563	0.0117
JK	1	-15.39492092	4.42749027	-3.477	0.0007

DAY 27 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	23	56920.17077	2474.79003	11.863	0.0001
ERROR	104	21695.32923	208.60893		
C TOTAL	127	78615.50000			

ROOT MSE	14.4433	R-SQUARE	0.7240
DEP MEAN	51.5625	ADJ R-SQ	0.6630
C.V.	28.01125		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	30.69559955	3.13740035	9.784	0.0001	INTERCEPT
B1	1	-19.25000000	3.37761767	-5.699	0.0001	
B2	1	-1.43750000	3.37761767	-0.426	0.6713	
B3	1	12.81250000	3.37761767	3.793	0.0002	
B4	1	10.12500000	3.37761767	2.998	0.0034	
B5	1	7.62500000	3.37761767	2.258	0.0261	
B6	1	1.12500000	3.37761767	0.333	0.7397	
B7	1	-22.18750000	3.37761767	-6.569	0.0001	
B	1	7.05958292	4.17071546	1.693	0.0935	Filler Aircraft
C	1	12.38949230	3.39934966	3.645	0.0004	ABDR
G	1	14.78851167	4.50716231	3.281	0.0014	Support Equip
AK	1	-8.01728625	3.43910949	-2.331	0.0217	Attrition & Fuel
BH	1	16.16540467	4.46531485	3.620	0.0005	Fillers & Spares
BK	1	7.96542949	4.60801252	1.729	0.0868	FILLERS & FUEL
CE	1	-14.90398461	4.48845135	-3.321	0.0012	ABDR & Personnel
DG	1	-7.63846822	4.08683008	-1.869	0.0644	Recovery & Spt Equip
DH	1	7.02693644	3.82837913	1.835	0.0693	Recovery & Spares
EG	1	-10.27898461	4.48845135	-2.290	0.0240	Personnel & Spt Equip
EH	1	6.88642006	4.09848284	1.680	0.0960	Personnel & Spares
EJ	1	18.32553378	3.80463175	4.817	0.0001	Personnel & Missiles
FK	1	13.42021475	3.43910949	3.902	0.0002	AIS & Fuel
GK	1	10.84042949	4.60801252	2.353	0.0205	SPT EQUIP & FUEL
HK	1	-11.99416584	4.17459411	-2.873	0.0049	SPARES & FUEL
JK	1	-12.80505214	3.85198010	-3.324	0.0012	MISSILES & FUEL

DAY 28 -- REDUCED MODEL WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	21	49340.64211	2349.55439	9.654	0.0001
ERROR	106	25797.23289	243.37012		
C TOTAL	127	75137.87500			

ROOT MSE	15.60032	R-SQUARE	0.6567
DEP MEAN	48.71875	ADJ R-SQ	0.5886
C.V.	32.02119		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	28.64880952	3.54611446	8.079	0.0001
B1	1	-18.96875000	3.64819182	-5.199	0.0001
B2	1	-0.65625000	3.64819182	-0.180	0.8576
B3	1	10.34375000	3.64819182	2.835	0.0055
B4	1	6.53125000	3.64819182	1.790	0.0763
B5	1	7.34375000	3.64819182	2.013	0.0467
B6	1	2.03125000	3.64819182	0.557	0.5788
B7	1	-21.71875000	3.64819182	-5.953	0.0001
B	1	15.92261905	4.55230501	3.498	0.0007
C	1	11.30877976	3.51190677	3.220	0.0017
G	1	11.99702381	5.23096958	2.293	0.0238
AK	1	-6.06398810	3.68795904	-1.644	0.1031
BG	1	-9.75000000	5.51554759	-1.768	0.0800
BH	1	12.46726190	4.69589111	2.655	0.0092
CE	1	-16.43005952	4.34887242	-3.778	0.0003
EJ	1	16.92261905	3.84814695	4.398	0.0001
FG	1	-11.24107143	4.69589111	-2.394	0.0184
FH	1	9.72619048	4.15001458	2.344	0.0210
FK	1	15.44345238	4.26478317	3.621	0.0005
GK	1	12.43452381	4.89723414	2.539	0.0126
HK	1	-7.72321429	4.26478317	-1.811	0.0730
JK	1	-13.96279762	4.06181058	-3.438	0.0008

DAY 29 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	21	41083.66432	1956.36497	9.099	0.0001
ERROR	106	22791.39037	215.01312		
C TOTAL	127	63875.05469			

ROOT MSE	14.66333	R-SQUARE	0.6432
DEP MEAN	46.58594	ADJ R-SQ	0.5725
C.V.	31.47586		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	32.77754548	2.83203207	11.574	0.0001
B1	1	-17.39843750	3.42907128	-5.074	0.0001
B2	1	-1.02343750	3.42907128	-0.298	0.7659
B3	1	8.41406250	3.42907128	2.454	0.0158
B4	1	9.66406250	3.42907128	2.818	0.0058
B5	1	7.97656250	3.42907128	2.326	0.0219
B6	1	0.78906250	3.42907128	0.230	0.8185
B7	1	-20.08593750	3.42907128	-5.858	0.0001
C	1	10.69591158	3.30135109	3.240	0.0016
G	1	11.01497294	4.63623253	2.376	0.0193
AK	1	-7.03604264	3.48948502	-2.016	0.0463
BH	1	16.19613980	3.63799774	4.452	0.0001
BK	1	11.36588745	3.78253480	3.005	0.0033
CE	1	-13.86057316	4.08889183	-3.390	0.0010
DG	1	-10.33605569	4.12303765	-2.507	0.0137
DH	1	8.04711137	3.77418584	2.132	0.0353
EJ	1	16.97114632	3.62254969	4.685	0.0001
FG	1	-7.18430490	4.16616772	-1.724	0.0875
FK	1	12.74360981	3.95910782	3.219	0.0017
GK	1	9.52168471	4.67219256	2.038	0.0440
HK	1	-11.47016823	3.94758201	-2.906	0.0045
JK	1	-13.14661561	3.85049546	-3.414	0.0009

DAY 30 -- REDUCED MODEL -- WITH ATTACK

DEP VARIABLE: SORTIES

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	18	36574.44778	2031.91377	10.467	0.0001
ERROR	109	21159.60691	194.12463		
C TOTAL	127	57734.05469			

ROOT MSE	13.93287	R-SQUARE	0.6335
DEP MEAN	42.91406	ADJ R-SQ	0.5730
C.V.	32.46691		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|	VARIABLE LABEL
INTERCEP	1	23.34333882	2.97659846	7.842	0.0001	INTERCEPT
B1	1	-16.47656250	3.25825135	-5.057	0.0001	
B2	1	-1.72656250	3.25825135	-0.530	0.5973	
B3	1	9.58593750	3.25825135	2.942	0.0040	
B4	1	8.21093750	3.25825135	2.520	0.0132	
B5	1	8.33593750	3.25825135	2.558	0.0119	
B6	1	-2.22656250	3.25825135	-0.683	0.4958	
B7	1	-17.10156250	3.25825135	-5.249	0.0001	
B	1	17.45764803	4.42223488	3.948	0.0001	Filler Aircraft
C	1	8.44202303	3.23366042	2.611	0.0103	ABDR
G	1	17.35320724	3.98552283	4.354	0.0001	Support Equip
BE	1	-9.79029605	4.19054109	-2.336	0.0213	Fillers & Personnel
BG	1	-9.28125000	4.92601302	-1.884	0.0622	Fillers & Spt Equip
BH	1	14.37500000	3.48321721	4.127	0.0001	Fillers & Spares
CE	1	-8.85279605	4.19054109	-2.113	0.0369	ABDR & Personnel
EJ	1	15.43338816	3.52875139	4.374	0.0001	Personnel & Missiles
FG	1	-12.14391447	3.87380440	-3.135	0.0022	AIS & SPT EQUIP
FK	1	16.22532895	3.39031467	4.786	0.0001	AIS & Fuel
JK	1	-14.18832237	3.34289535	-4.244	0.0001	MISSILES & FUEL

Appendix E: Residual Results for Attack Case

DAY 1 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID   RESIDUALS

MOMENTS

N	126	SUM WGTS	126
MEAN	2.220E-15	SUM	2.842E-13
STD DEV	9.69367	VARIANCE	93.9673
SKEWNESS	0.319628	KURTOSIS	1.03063
USS	11933.8	CSS	11933.8
CV	99999	STD MEAN	0.856606
T:MEAN=0	2.592E-15	PROB>|T|	1
SGN RANK	-152	PROB>|S|	0.716625
NUM ^= 0	126		
D:NORMAL	0.063731	PROB>D	>.15

QUANTILES(DEF=4)

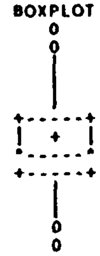
100% MAX	30.5156	99%	29.9356
75% Q3	5.55469	95%	19.1641
50% MED	-0.4375	90%	11.7656
25% Q1	-5.48438	10%	-10.3344
0% MIN	-26.3906	5%	-15.9406
		1%	-25.5206
RANGE	56.9063		
Q3-Q1	11.0391		
MODE	-5.48438		

EXTREMES

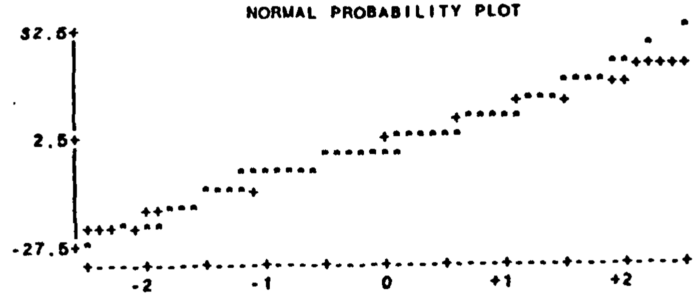
LOWEST	HIGHEST
-26.3906	19.5156
-23.3906	21.5156
-20.3906	21.7344
-20.3906	26.5156
-18.3906	30.5156

```
STEM LEAF                                  #
   3 1                                     1
   2 9                                     1
   2 0022                                  4
   1 699                                   3
   1 000112234                             9
   0 55555566677777778889                 20
   0 11111222223333333444                 20
  -0 44444433333333222211111100000000     32
  -0 999888887777766665555555             24
  -1 332200                                6
  -1 8655                                  4
  -2 300                                   3
  -2 6                                     1
     ----+----+----+----+----+----+--
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 2 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	3.832E-15	SUM	4.905E-13
STD DEV	15.2725	VARIANCE	233.25
SKEWNESS	-1.02829	KURTOSIS	1.74445
USS	29622.8	CSS	29622.8
CV	99999	STD MEAN	1.34991
T:MEAN=0	2.839E-15	PROB>|T|	1
SGN RANK	399.5	PROB>|S|	0.34288
NUM ^= 0	128		
D:NORMAL	0.0999464	PROB>D	<.01

QUANTILES(DEF=4)

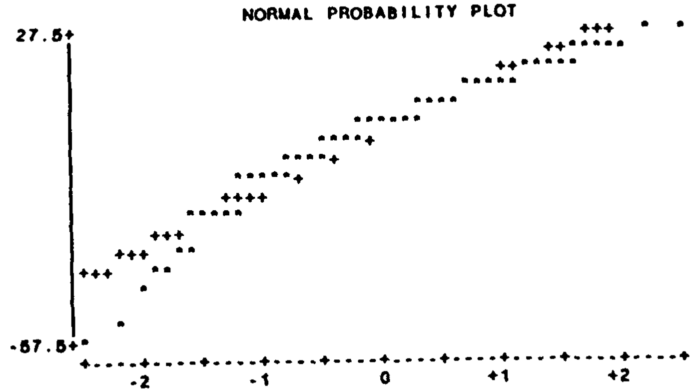
100% MAX	28.5626	99%	28.5593
75% Q3	10.25	95%	20.5303
50% MED	2.16973	90%	18.1719
25% Q1	-6.85156	10%	-20.8357
0% MIN	-55.2567	5%	-32.5904
		1%	-54.083
RANGE	83.8393		
Q3-Q1	17.1016		
MODE	-13.6183		

EXTREMES

LOWEST	HIGHEST
-55.2567	22.8504
-51.1408	23.3817
-40.6317	24.8504
-39.9621	28.5022
-37.2748	28.5626

```
STEM LEAF                        #             BOXPLOT
   2 599                         3                |
   2 0133                        4                |
   1 5677899999                 10                |
   1 000000011222222333344      20             +-----+
   0 5555666678899999           16             |     |
   0 112222222223333444         18             *--+--*
  -0 444444222211100            15             |     |
  -0 977777778666555            15             +-----+
  -1 444433321111               12                |
  -1 5                           1                |
  -2 4322110                     7                |
  -2                                              |
  -3 32                          2                0
  -3 7                           1                0
  -4 10                          2                0
  -4
  -5 1                           1                0
  -5 5                           1                0
     ----+----+----+----+
 MULTIPLY STEM.LEAF BY 10**+01
```

NORMAL PROBABILITY PLOT



DAY 3 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	3.997E-15	SUM	5.116E-13
STD DEV	23.4095	VARIANCE	548.008
SKEWNESS	-0.824084	KURTOSIS	0.881478
USS	69596.8	CSS	69596.8
CV	99999	STD MEAN	2.06913
T:MEAN=0	1.932E-15	PROB>|T|	1
SGN RANK	288	PROB>|S|	0.494153
NUM ^= 0	128		
D:NORMAL	0.0910437	PROB>D	<.01

QUANTILES(DEF=4)

100% MAX	39.6344	99%	38.8157
75% Q3	16.8516	95%	32.9737
50% MED	4.09887	90%	29.1837
25% Q1	-12.5656	10%	-34.8012
0% MIN	-88.2531	5%	-40.654
		1%	-61.6157
RANGE	127.887		
Q3-Q1	29.2172		
MODE	-12.5656		

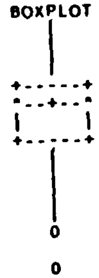
EXTREMES

LOWEST	HIGHEST
-88.2531	33.2469
-65.3656	33.4156
-55.1719	33.7781
-50.9719	36.1219
-41.1989	39.6344

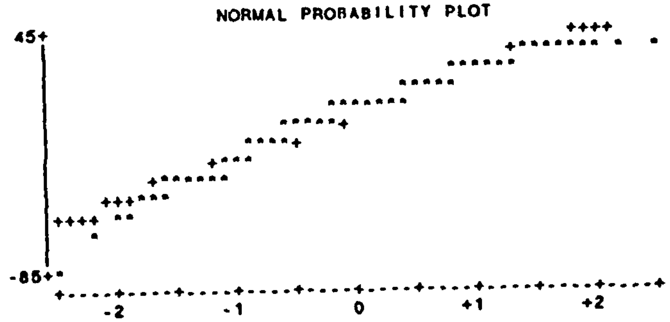
STEM	LEAF	#
4	0	1
3	0011333348	10
2	011223556788999	15
1	000122334444667778999	21
0	1223444445555666777888899	25
-0	9888776666654444310	19
-1	9978443332200	13
-2	9721110	7
-3	9877654432	10
-4	110	3
-5	51	2
-6	5	1
-7		
-8	8	1

MULTIPLY STEM.LEAF BY 10**+01

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 4 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	9.326E-15	SUM	1.194E-12
STD DEV	18.8332	VARIANCE	354.69
SKEWNESS	-0.296215	KURTOSIS	0.0733345
USS	45045.7	CSS	45045.7
CV	99999	STD MEAN	1.66464
T:MEAN=0	5.602E-15	PROB>|T|	1
SGN RANK	178	PROB>|S|	0.872938
NUM ^= 0	128		
D:NORMAL	0.0802853	PROB>D	0.042

QUANTILES(DEF=4)

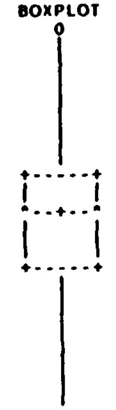
100% MAX	50.8649	99%	49.1374
75% Q3	13.0139	95%	28.2143
50% MED	3.27718	90%	23.2355
25% Q1	-11.6169	10%	-25.3757
0% MIN	-47.5192	5%	-34.4064
		1%	-47.0614
RANGE	98.3841		
Q3-Q1	24.6309		
MODE	-47.5192		

EXTREMES

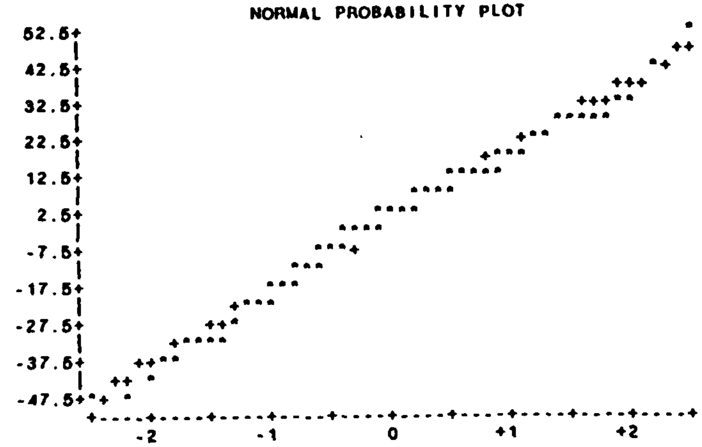
LOWEST	HIGHEST
-47.5192	29.8462
-45.9404	30.0394
-44.3755	33.3452
-38.8462	44.9082
-36.6038	50.8649

```
STEM LEAF                    #
   5 1                       1
   4 5                       1
   4
   3
   3 003                     3
   2 5566779                 7
   2 1223                    4
   1 55666666                8
   1 000011223333333444     18
   0 555566777899999        15
   0 1222333333444          13
  -0 444443211000           12
  -0 977766655               9
  -1 443211100               9
  -1 98887755                8
  -2 43220                   5
  -2 8555                    4
  -3 444441                  6
  -3 97                      2
  -4 4                       1
  -4 86                      2
     ----+----+----+----+
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 5 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.554E-14	SUM	1.990E-12
STD DEV	22.7921	VARIANCE	519.481
SKEWNESS	-0.816242	KURTOSIS	1.93674
USS	65974.1	CSS	65974.1
CV	99999	STD MEAN	2.01456
T:MEAN=0	7.715E-15	PROB>|T|	1
SGN RANK	196	PROB>|S|	0.641983
NUM ^= 0	128		
D:NORMAL	0.0541484	PROB>D	>.15

QUANTILES(DEF=4)

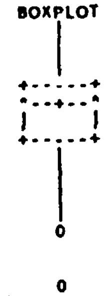
100% MAX	41.9808	99%	41.7359
75% Q3	14.9865	95%	35.1864
50% MED	1.06277	90%	28.8211
25% Q1	-14.8415	10%	-25.4629
0% MIN	-97.3443	5%	-39.1715
		1%	-87.3513
RANGE	139.325		
Q3-Q1	29.828		
MODE	-97.3443		

EXTREMES

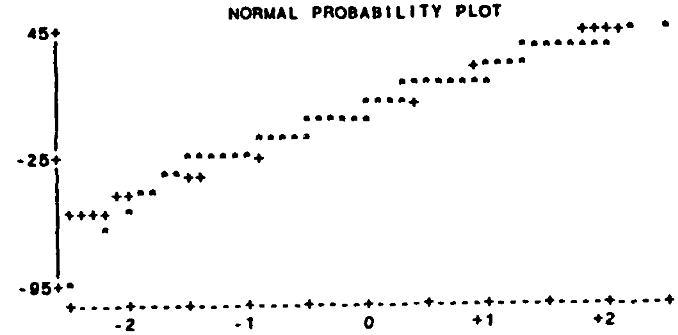
LOWEST	HIGHEST
-97.3443	37.653
-62.8858	39.1218
-57.423	39.5102
-48.6148	41.1369
-42.4063	41.9808

```
STEM LEAF                              #
   4 012                               3
   3 001145669                         9
   2 0013445669                       10
   1 001222334444555555666677899      27
   0 1122345556777789                 16
  -0 999987766655333222221110         24
  -1 9888766555443321                 16
  -2 987755533221100                  15
  -3 88                                2
  -4 920                               3
  -5 7                                 1
  -6 3                                 1
  -7
  -8
  -9 7                                 1
     ----+----+----+----+----+--
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 6 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

```
VARIABLE=YRESID          RESIDUALS

                 MOMENTS                                             QUANTILES(DEF=4)                               EXTREMES

N               128  SUM WGTS          128      100% MAX    65.7065    99%    59.2238        LOWEST    HIGHEST
MEAN      1.377E-14  SUM         1.782E-12       75% Q3     20.1071    95%    39.0818      -119.831    39.6604
STD DEV     29.9203  VARIANCE      895.223       50% MED    3.42448    90%    31.2984       -117.91    39.7779
SKEWNESS    -1.4567  KURTOSIS      3.77156       25% Q1    -13.5331    10%   -35.2746      -104.769    41.5435
USS          113693  CSS            113693        0% MIN   -119.831     5%   -53.5292      -77.9624    43.3523
CV            99999  STD MEAN       2.6446                              1%   -119.274      -57.7593    65.7065
T:MEAN=0  5.206E-15  PROB>|T|            1      RANGE       185.537
SGN RANK        527  PROB>|S|     0.210535      Q3-Q1       33.6402
NUM ^= 0        128                             MODE       -119.831
D:NORMAL   0.106847  PROB>D           <.01

STEM LEAF                          #     BOXPLOT                 NORMAL PROBABILITY PLOT
   6 6                             1                        65+
   5
   4 00023                         5
   3 00011223678                  11
   2 0133334445566678             15
   1 00123344455566788899         20
   0 111133345677777899           18
  -0 9998776655444433111110       21
  -1 8877666654422100             16                       -25+
  -2 9975411                       7
  -3 50                            2
  -4 7431                          4
  -5 8521                          4
  -6
  -7 6                             1        0
  -8
  -9
 -10 5                             1        0
 -11 06                            2        *             -115+
     ----+----+----+----+-                                      -2      -1       0      +1      +2
 MULTIPLY STEM.LEAF BY 10**+01
```

```
DAY 7 -- ANALYSIS OF RESIDUALS -- WITH ATTACK
                   UNIVARIATE

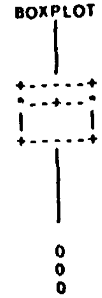
VARIABLE=YRESID         RESIDUALS

                   MOMENTS                                   QUANTILES(DEF=4)                              EXTREMES

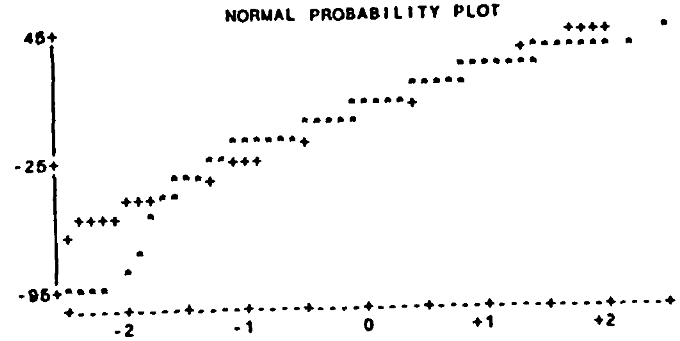
N                 128  SUM WGTS          128    100% MAX   43.2582     99%    42.206        LOWEST    HIGHEST
MEAN        1.732E-14  SUM         2.217E-12     75% Q3    17.7044     95%   33.9485      -94.3126    34.3459
STD DEV        24.732  VARIANCE      611.671     50% MED   2.33603     90%   27.7691      -94.3126    36.8749
SKEWNESS     -1.32136  KURTOSIS      3.25071     25% Q1   -12.2555     10%  -25.4744       -80.996    38.0312
USS           77682.3  CSS           77682.3      0% MIN  -94.3126      5%  -43.9724      -79.2179    39.6301
CV              99999  STD MEAN      2.18602                            1%  -94.3126      -50.7229    43.2582
T:MEAN=0    7.923E-16  PROB>|T|            1    RANGE      137.571
SGN RANK          424  PROB>|S|     0.313864    Q3-Q1        29.96
NUM ^= 0          128                           MODE      -94.3126
D:NORMAL    0.0887378  PROB>D          0.015

STEM LEAF                     #
   4 03                       2
   3 11244478                 8
   2 011122233356778889      18
   1 000223344567778889      18
   0 1112333345556777788899  22
  -0 9987666655554444322111  22
  -1 88877666644433111100    20
  -2 9543300                  7
  -3 4110                     4
  -4 53                       2
  -5 1                        1
  -6
  -7 9                        1
  -8 1                        1
  -9 44                       2
     ----+----+----+----+--
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 8 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	6.217E-15	SUM	7.958E-13
STD DEV	27.4832	VARIANCE	755.326
SKEWNESS	-1.62479	KURTOSIS	6.06239
USS	95926.4	CSS	95926.4
CV	99999	STD MEAN	2.42919
T:MEAN=0	2.559E-15	PROB>|T|	1
SGN RANK	462	PROB>|S|	0.252176
NUM ^= 0	128		
D:NORMAL	0.102003	PROB>D	<.01

QUANTILES(DEF=4)

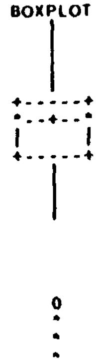
100% MAX	52.4772	99%	50.4717
75% Q3	18.2791	95%	33.7976
50% MED	1.23089	90%	28.8532
25% Q1	-12.3796	10%	-26.9224
0% MIN	-122.247	5%	-36.4043
		1%	-119.646
RANGE	174.724		
Q3-Q1	30.6586		
MODE	-122.247		

EXTREMES

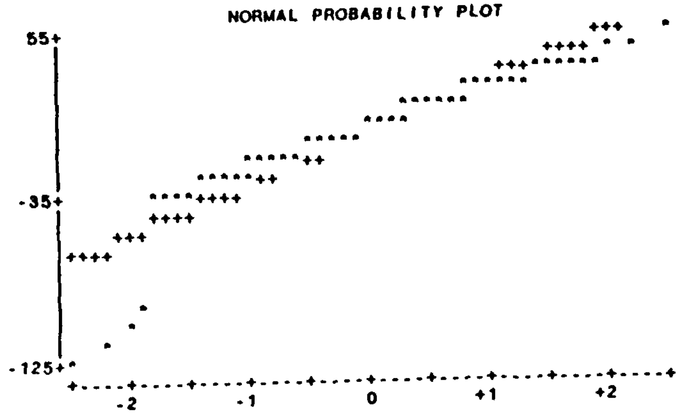
LOWEST	HIGHEST
-122.247	34.8212
-113.277	39.0457
-104.726	40.3587
-93.6413	45.5618
-39.5322	52.4772

```
STEM LEAF                          #
  5 2                              1
  4 06                             2
  3 001223559                      9
  2 002344445667899               15
  1 00001223356666677799999       23
  0 122233556788999               15
 -0 99878666665555444333322200 0  26
 -1 9765544433311111              16
 -2 998754321111                  12
 -3 7510                           4
 -4 0                              1
 -5
 -6
 -7
 -8
 -9 4                              1
-10 5                              1
-11 3                              1
-12 2                              1
    ----+----+----+----+----+-
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 9 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.332E-15	SUM	1.705E-13
STD DEV	24.3402	VARIANCE	592.445
SKEWNESS	-1.7430	KURTOSIS	4.98825
USS	75240.5	CSS	75240.5
CV	99999	STD MEAN	2.15139
T:MEAN=0	6.193E-16	PROB>|T|	1
SGN RANK	578	PROB>|S|	0.169833
NUM ^= 0	128		
D:NORMAL	0.106133	PROB>D	<.01

QUANTILES(DEF=4)

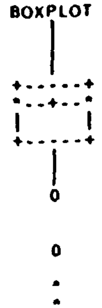
100% MAX	43.6875	99%	41.4536
75% Q3	14.5664	95%	31.0256
50% MED	4.78125	90%	25.7344
25% Q1	-10.6172	10%	-26.6359
0% MIN	-100.891	5%	-42.9078
		1%	-100.401
RANGE	144.578		
Q3-Q1	25.1836		
MODE	14.4375		

EXTREMES

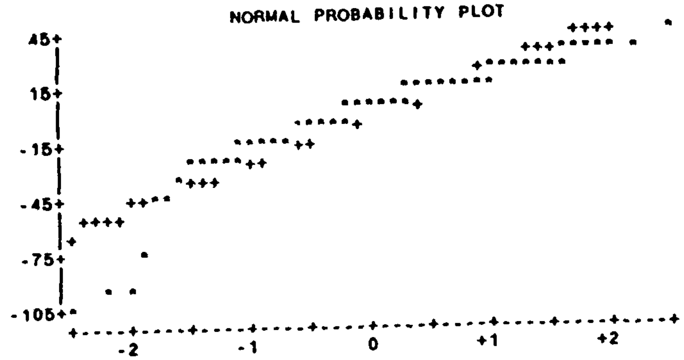
LOWEST	HIGHEST
-100.891	32.1094
-99.2031	32.2187
-94.8438	35.4063
-70.5313	35.9844
-48.5781	43.6875

```
STEM LEAF                              #
   4 4                                 1
   3 112258                            6
   2 11123334666788                   14
   1 111222233334444445555667788889   27
   0 2222334455555666778889999        25
  -0 9988876554433333321110           22
  -1 99987655544211                   14
  -2 99877543300                      11
  -3 60                                2
  -4 98                                2
  -5
  -6
  -7 1                                 1
  -8
  -9 95                                2
 -10 1                                 1
     ----+----+----+----+----+--
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 10 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.132E-14	SUM	2.728E-12
STD DEV	25.624	VARIANCE	651.472
SKEWNESS	-1.16667	KURTOSIS	2.20203
USS	82737	CSS	82737
CV	99999	STD MEAN	2.25602
T:MEAN=0	9.449E-15	PROB>|T|	1
SGN RANK	423	PROB>|S|	0.315006
NUM ^= 0	128		
D:NORMAL	0.0838253	PROB>D	0.025

QUANTILES(DEF=4)

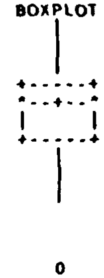
100% MAX	40.0544	99%	39.5238
75% Q3	16.862	95%	37.1273
50% MED	2.99857	90%	29.6202
25% Q1	-12.0136	10%	-32.4726
0% MIN	-89.2948	5%	-43.0541
		1%	-88.8118
RANGE	129.349		
Q3-Q1	28.8955		
MODE	-4.85448		

EXTREMES

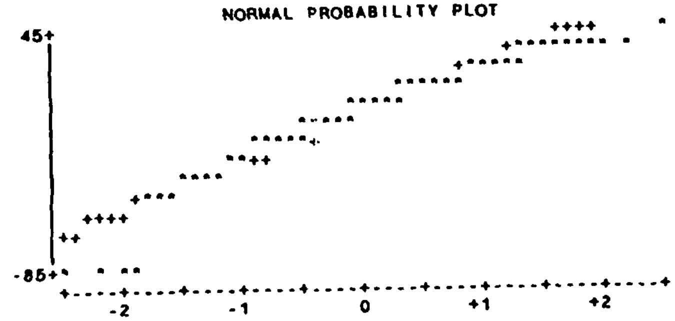
LOWEST	HIGHEST
-89.2948	37.5639
-87.6293	37.572
-84.8293	37.833
-80.8655	38.2247
-46.2204	40.0544

```
STEM LEAF                       #
   4 0                          1
   3 11446778888               11
   2 00000112345566899         17
   1 00011233345555677779      20
   0 112233335677888889999     21
  -0 9876555554443111100       19
  -1 8887653321111000          16
  -2 8421100                    7
  -3 76552110                   8
  -4 6331                       4
  -5
  -6
  -7
  -8 9851                       4
     ----+----+----+----+-
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 11 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	8.438E-15	SUM	1.080E-12
STD DEV	22.2721	VARIANCE	496.046
SKEWNESS	-0.603004	KURTOSIS	1.93064
USS	62997.6	CSS	62997.6
CV	99999	STD MEAN	1.96859
T:MEAN=0	4.286E-15	PROB>|T|	1
SGN RANK	62	PROB>|S|	0.883719
NUM ^= 0	128		
D:NORMAL	0.0808787	PROB>D	0.039

QUANTILES(DEF=4)

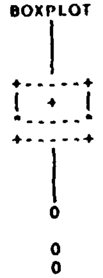
100% MAX	46.375	99%	47.36
75% Q3	14.5703	95%	38.8734
50% MED	-0.296875	90%	29.4594
25% Q1	-12.8437	10%	-23.6094
0% MIN	-87.25	5%	-32.8015
		1%	-83.2081
RANGE	135.625		
Q3-Q1	27.4141		
MODE	-14		

EXTREMES

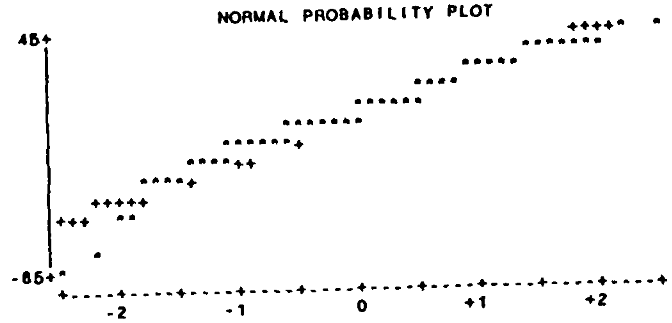
LOWEST	HIGHEST
-87.25	39.0938
-73.3125	39.2187
-56.0312	39.25
-55.7188	44.875
-33.5937	46.375

```
STEM LEAF                              #
   4 58                                2
   3 0156799999                       10
   2 0022333456679                    13
   1 1222345688889                    13
   0 112222222333334455557789         24
  -0 9998877666555444333221111000     28
  -1 988777654444433322100            21
  -2 96533321                          8
  -3 43320                             5
  -4
  -5 66                                2
  -6
  -7 3                                 1
  -8 7                                 1
     ----+----+----+----+----+---
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 12 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID   1ESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.021E-14	SUM	1.307E-12
STD DEV	20.6861	VARIANCE	427.874
SKEWNESS	-0.884122	KURTOSIS	2.52641
USS	54340	CSS	54340
CV	99999	STD MEAN	1.82832
T:MEAN=0	5.587E-15	PROB>|T|	1
SGN RANK	295	PROB>|S|	0.483699
NUM ^= 0	128		
D:NORMAL	0.0687778	PROB>D	0.015

QUANTILES(DEF=4)

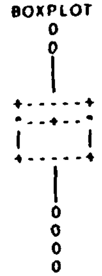
100% MAX	53.2083	99%	51.7765
75% Q3	11.0031	95%	30.671
50% MED	1.46354	90%	26.1815
25% Q1	-11.0375	10%	-25.6258
0% MIN	-78.1917	5%	-29.0621
		1%	-76.2299
RANGE	131.4		
Q3-Q1	22.0406		
MODE	-78.1917		

EXTREMES

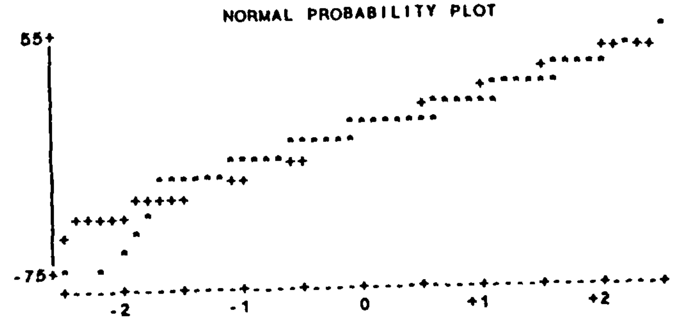
LOWEST	HIGHEST
-78.1917	32.1104
-71.4271	33.3125
-61.9668	33.4021
-56.0292	46.2708
-49.1437	53.2083

```
STEM LEAF                                  #
   5 3                                     1
   4 6                                     1
   3 01233                                 5
   2 4445667778                           10
   1 000111133334666777889                21
   0 11122233344444555566677788999        29
  -0 9887766555544443333322111100         28
  -1 7776665444333110                     16
  -2 999876663110                         12
  -3
  -4 9                                     1
  -5 6                                     1
  -6 2                                     1
  -7 81                                    2
     ----+----+----+----+----+----
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 13 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	4.441E-15	SUM	5.684E-13
STD DEV	21.9884	VARIANCE	483.492
SKEWNESS	-0.910697	KURTOSIS	2.46149
USS	61403.4	CSS	61403.4
CV	99999	STD MEAN	1.94352
T:MEAN=0	2.285E-15	PROB>|T|	1
SGN RANK	276	PROB>|S|	0.512352
NUM ^= 0	128		
D:NORMAL	0.0885873	PROB>D	0.144

QUANTILES(DEF=4)

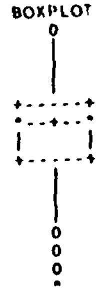
100% MAX	57.8359	99%	53.2322
75% Q3	13.8359	95%	29.6594
50% MED	0.375	90%	27.4187
25% Q1	-10.9336	10%	-23.8453
0% MIN	-88.7266	5%	-42.2476
		1%	-83.5428
RANGE	146.563		
Q3-Q1	24.7695		
MODE	0.523438		

EXTREMES

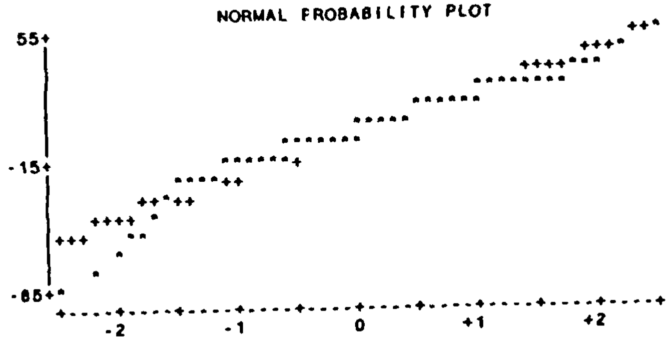
LOWEST	HIGHEST
-88.7266	31.8328
-70.8516	33.5234
-61.9609	36.3984
-54.4141	41.9609
-51.0547	57.8359

```
STEM LEAF                                  #
   5 8                                     1
   4 2                                     1
   3 00246                                 5
   2 12445557778899                       14
   1 000112233444556666999                21
   0 1111122445558666888999               22
  -0 99888777666554433222111111000        29
  -1 9988776554333211100                  19
  -2 99754110                              8
  -3 93                                    2
  -4 5                                     1
  -5 41                                    2
  -6 2                                     1
  -7 1                                     1
  -8 9                                     1
     ----+----+----+----+----+----
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 14 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.265E-14	SUM	2.899E-12
STD DEV	21.7677	VARIANCE	473.816
SKEWNESS	-0.883487	KURTOSIS	1.64309
USS	60149.3	CSS	60149.3
CV	99999	STD MEAN	1.92357
T MEAN=0	1.177E-14	PROB>|T|	1
SGN RANK	367	PROB>|S|	0.383431
NUM ^= 0	128		
D:NORMAL	0.115739	PROB>D	<.01

QUANTILES(DEF=4)

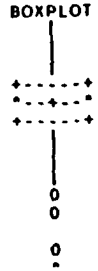
100% MAX	47.3313	99%	44.5409
75% Q3	14.6035	95%	33.0797
50% MED	2.14912	90%	23.7073
25% Q1	-7.83503	10%	-28.1354
0% MIN	-80.8062	5%	-39.2441
		1%	-77.8255
RANGE	127.938		
Q3-Q1	22.4385		
MODE	-80.8062		

EXTREMES

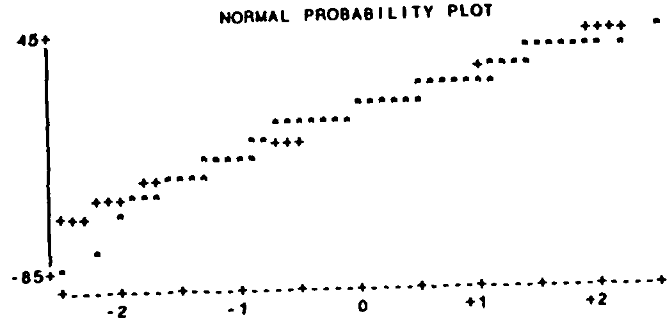
LOWEST	HIGHEST
-80.8062	33.8458
-71.0175	34.1224
-59.2839	37.0813
-48.6317	37.7095
-45.5125	47.3313

```
STEM LEAF                                      #
   4 7                                         1
   3 112334478                                 9
   2 00012233447                              11
   1 000122344455677777899                    21
   0 23344455666877778889999                  23
  -0 9987777866655555544433222222000000       34
  -1 886531                                    6
  -2 88855543111                              11
  -3 632220                                    6
  -4 982                                       3
  -5 9                                         1
  -6
  -7 1                                         1
  -8 1                                         1
     ----+----+----+----+----+----+----
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



```
                                  DAY 15 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

                                                  UNIVARIATE

VARIABLE=YRESID         RESIDUALS

               MOMENTS                                          QUANTILES(DEF=4)                                  EXTREMES

N                   128  SUM WGTS          128       100% MAX    45.6432     99%     44.1071           LOWEST    HIGHEST
MEAN          1.066E-14  SUM         1.364E-12        75% Q3     12.8594     95%     36.0206         -77.9089    36.8901
STD DEV         22.2142  VARIANCE      493.472        50% MED   0.898437     90%     27.1408         -76.4089    37.9505
SKEWNESS       -0.88061  KURTOSIS      2.02698        25% Q1    -12.7018     10%    -22.7323         -70.4661    39.0026
USS             62870.9  CSS           62870.9         0% MIN   -77.9089      5%    -43.7591          -53.362    40.3464
CV                99999  STD MEAN      1.96346                                1%    -77.4738         -51.8203    45.6432
T MEAN=0      5.428E-16  PROB>|T|            1       RANGE       123.552
SGN RANK            250  PROB>|S|     0.552948       Q3-Q1       25.5612
NUM ^= 0            128                              MODE        5.39323
D:NORMAL      0.0787238  PROB>D           0.05

STEM LEAF                                  #      BOXPLOT                          NORMAL PROBABILITY PLOT
   4 06                                    2         |              45+                                               +++*   *
   3 24566789                              8         |                |                                      ********
   2 1123446677788                        13      +-----+              |                              ******
   1 1111223334445666                     16      *--+--*              |                        *******
   0 1222344455555555666677889            25      |     |              |                  *****
  -0 99887766665543333322110000000        29      +-----+           -15+           ********+
  -1 9987777766554333220                  19         |                |       ***++
  -2 7733000                               7         |                |    ++***+
  -3 520                                   3         |                |  ++++
  -4                                                 |                |+++***
  -5 321                                   3         0                |
  -6                                                                  |
  -7 660                                   3         0             -75+*  * *
     ----+----+----+----+----+----                                    +----+----+----+----+----+----+----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01                                              -2        -1         0        +1        +2
```

DAY 18 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

```
VARIABLE=YRESID          RESIDUALS

                 MOMENTS

N                 128   SUM WGTS            128
MEAN        1.288E-14   SUM           1.648E-12
STD DEV       20.8475   VARIANCE        434.618
SKEWNESS    -0.587248   KURTOSIS       0.778856
USS           55196.5   CSS             55196.5
CV              99999   STD MEAN        1.84267
T:MEAN=0    6.989E-15   PROB>|T|              1
SGN RANK          235   PROB>|S|       0.577066
NUM ^= 0          128
D:NORMAL     0.076961   PROB>D            0.063

               QUANTILES(DEF=4)

100% MAX      45.7422       99%      44.1925
 75% Q3       13.4844       95%      32.1487
 50% MED     0.921875       90%      27.2016
 25% Q1      -10.4753       10%     -24.9812
  0% MIN     -71.4766        5%     -39.0825
                             1%      -66.033

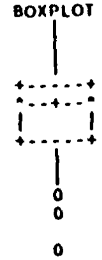
RANGE         117.219
Q3-Q1         23.9598
MODE          8.38281

          EXTREMES

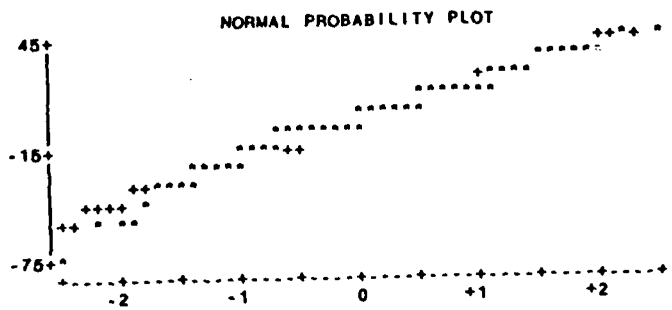
   LOWEST      HIGHEST
 -71.4766      34.1538
 -52.7057      34.9453
 -52.6172      34.9922
 -50.9922      40.3984
 -49.9922      45.7422

STEM LEAF                                          #
   4 06                                            2
   3 1122455                                       7
   2 0566777788                                   10
   1 0012233334445556667779                       22
   0 22234444455577888999999                      23
  -0 99988777888865555554332221111110             32
  -1 998776644311                                 12
  -2 9754443100                                   10
  -3 8431                                          4
  -4 0                                             1
  -5 3310                                          4
  -6
  -7 1                                             1
     ----+----+----+----+----+----+--
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 17 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

```
VARIABLE=YRESID          RESIDUALS

                     MOMENTS

N                128  SUM WGTS          128
MEAN       2.678E-14  SUM         3.297E-12
STD DEV      20.5964  VARIANCE      424.211
SKEWNESS   -0.176074  KURTOSIS     0.810524
USS          53674.8  CSS           53674.8
CV             99999  STD MEAN      1.82048
T:MEAN=0   1.415E-14  PROB>|T|            1
SGN RANK         109  PROB>|S|     0.796384
NUM ^= 0         128
D:NORMAL   0.0493787  PROB>D          >.15

                QUANTILES(DEF=4)

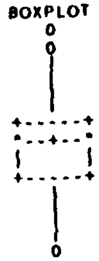
100% MAX     63.8452      99%     60.5231
 75% Q3      12.0445      95%     29.3849
 50% MED    0.256152      90%     26.7601
 25% Q1     -11.9078      10%    -25.4611
  0% MIN    -59.9673       5%    -36.7314
                           1%    -59.9673
RANGE        123.813
Q3-Q1        23.9523
MODE        -59.9673

         EXTREMES

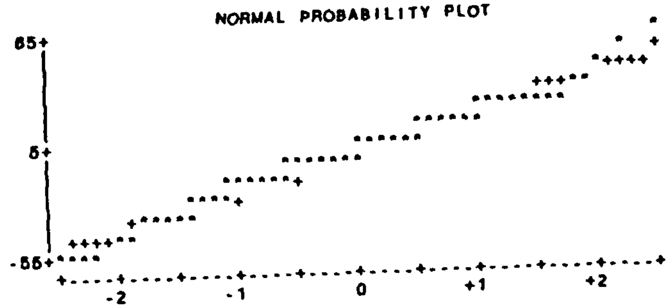
  LOWEST     HIGHEST
-59.9673     31.2426
-59.9673     36.8434
-43.6194     40.9665
-41.7173     52.3896
 -38.447     63.8452

STEM LEAF                                   #
   6 4                                      1
   5 2                                      1
   4 1                                      1
   3 017                                    3
   2 12333347777889                        14
   1 00011122222335556788899               21
   0 1223333334455666788899                22
  -0 99888876666654443222211111000         29
  -1 9987655433221100                      16
  -2 9654433200                            10
  -3 877654                                 6
  -4 42                                     2
  -5 00                                     2
     ----+----+----+----+----+----
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 16 -- *ANALYSIS OF RESIDUALS* -- *WITH ATTACK*

UNIVARIATE

VARIABLE=YRESID *RESIDUALS*

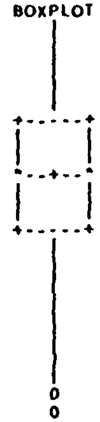
MOMENTS			
N	128	SUM WGTS	128
MEAN	2.265E-14	SUM	2.899E-12
STD DEV	19.9922	VARIANCE	399.69
SKEWNESS	-0.803766	KURTOSIS	0.48484
USS	50760.6	CSS	50760.6
CV	99999	STD MEAN	1.76706
T:MEAN=0	1.282E-14	PROB>|T|	1
SGN RANK	241	PROB>|S|	0.567359
NUM ^= 0	128		
D:NORMAL	0.0649525	PROB>D	>.15

QUANTILES(DEF=4)			
100% MAX	44.3066	99%	41.6387
75% Q3	16.3236	95%	29.1466
50% MED	0.852419	90%	22.6619
25% Q1	-12.3199	10%	-25.213
0% MIN	-62.6135	5%	-33.4835
		1%	-60.6566
RANGE	107.12		
Q3-Q1	26.6436		
MODE	-62.6135		

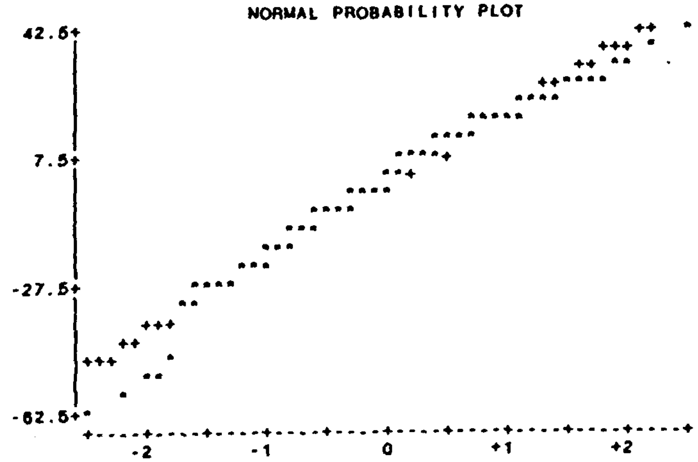
EXTREMES	
LOWEST	HIGHEST
-62.6135	29.9631
-55.376	32.5313
-52.4251	34.3979
-52.106	35.1064
-46.6127	44.3066

```
STEM LEAF                      #
   4 4                         1
   3 5                         1
   3 034                       3
   2 555699                    6
   2 0000022334               10
   1 5577788899999            13
   1 00001222444              11
   0 667777666999             12
   0 1222334                   7
  -0 4443321100000            13
  -0 999987777666665          15
  -1 444331100                 9
  -1 766655                    6
  -2 44433221                  8
  -2 997775                    6
  -3 2                         1
  -3 5                         1
  -4
  -4 7                         1
  -5 22                        2
  -5 5                         1
  -6 3                         1
     ----+----+----+----+
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 19 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.132E-14	SUM	2.728E-12
STD DEV	20.5974	VARIANCE	424.254
SKEWNESS	-0.321395	KURTOSIS	0.309622
USS	53880.2	CSS	53880.2
CV	99999	STD MEAN	1.82057
T:MEAN=0	1.171E-14	PROB>|T|	1
SGN RANK	145	PROB>|S|	0.731115
NUM ^= 0	128		
D:NORMAL	0.0419273	PROB>D	>.15

QUANTILES(DEF=4)

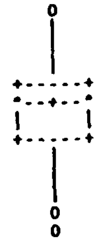
100% MAX	57.631	99%	50.8594
75% Q3	14.4251	95%	31.7029
50% MED	1.38994	90%	27.812
25% Q1	-13.434	10%	-26.2549
0% MIN	-60.2066	5%	-33.8427
		1%	-59.3766
RANGE	117.838		
Q3-Q1	27.8591		
MODE	-60.2066		

EXTREMES

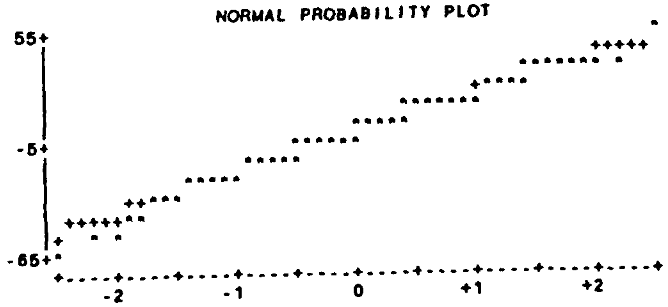
LOWEST	HIGHEST
-60.2066	31.9845
-57.3445	32.3976
-51.6799	32.9909
-43.1637	34.2805
-42.1963	57.631

```
STEM LEAF                          #
   5 8                             1
   4
   3 0012222234                   10
   2 012266788                     9
   1 011223334444455666777889     24
   0 122223444444677888999        21
  -0 98887776554444333211110      23
  -1 987765444333222110           18
  -2 776655411100                 12
  -3 62000                         5
  -4 32                            2
  -5 72                            2
  -6 0                             1
     ----+----+----+----+----
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 20 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	3.597E-14	SUM	4.604E-12
STD DEV	17.9108	VARIANCE	320.798
SKEWNESS	0.0700696	KURTOSIS	0.201512
USS	40741.1	CSS	40741.1
CV	99999	STD MEAN	1.5831
T MEAN=0	2.272E-14	PROB>|T|	1
SGN RANK	10	PROB>|S|	0.981975
NUM ^= 0	128		
D:NORMAL	0.0604252	PROB>D	>.15

QUANTILES(DEF=4)

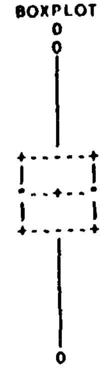
100% MAX	47.606	99%	46.7615
75% Q3	10.5104	95%	31.8784
50% MED	0.20404	90%	23.5993
25% Q1	-9.95117	10%	-22.7102
0% MIN	-42.4036	5%	-30.5545
		1%	-42.3186
RANGE	90.0098		
Q3-Q1	20.4615		
MODE	-38.1934		

EXTREMES

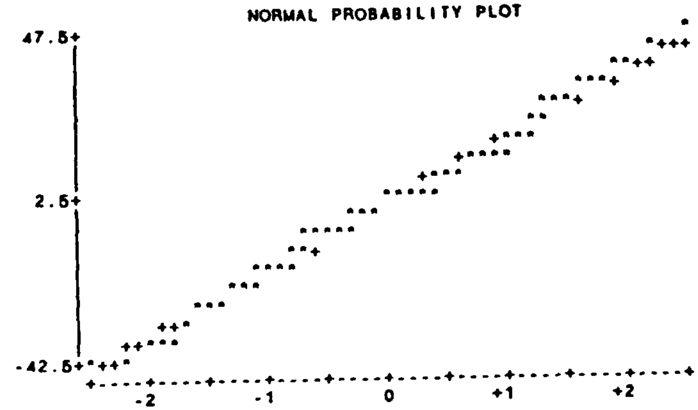
LOWEST	HIGHEST
-42.4036	34.7793
-42.1099	37.4865
-38.1934	39.8735
-38.1934	44.6938
-36.7483	47.606

```
STEM LEAF                    #
   4 56                      2
   4 0                       1
   3 57                      2
   3 0013                    4
   2 666                     3
   2 0133                    4
   1 66799                   5
   1 0011122233444          13
   0 55556677777899         14
   0 11222233344444         14
  -0 4221111100000000       16
  -0 99999888776666555      17
  -1 4431100                 7
  -1 998887765               9
  -2 432210                  6
  -2 88655                   5
  -3 2                       1
  -3 887                     3
  -4 22                      2
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 21 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	3.863E-14	SUM	4.714E-12
STD DEV	16.9933	VARIANCE	288.773
SKEWNESS	-0.401764	KURTOSIS	0.1605
USS	36674.2	CSS	36674.2
CV	99999	STD MEAN	1.50201
T MEAN=0	2.452E-14	PROB>|T|	1
SGN RANK	177	PROB>|S|	0.674673
NUM ^= 0	128		
D:NORMAL	0.0516803	PROB>D	>.15

QUANTILES(DEF=4)

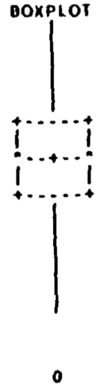
100% MAX	38.2761	99%	36.7363
75% Q3	11.2847	95%	24.9856
50% MED	0.298373	90%	21.5284
25% Q1	-9.73079	10%	-21.8829
0% MIN	-56.1518	5%	-31.9385
		1%	-50.6809
RANGE	94.4279		
Q3-Q1	20.9955		
MODE	-56.1518		

EXTREMES

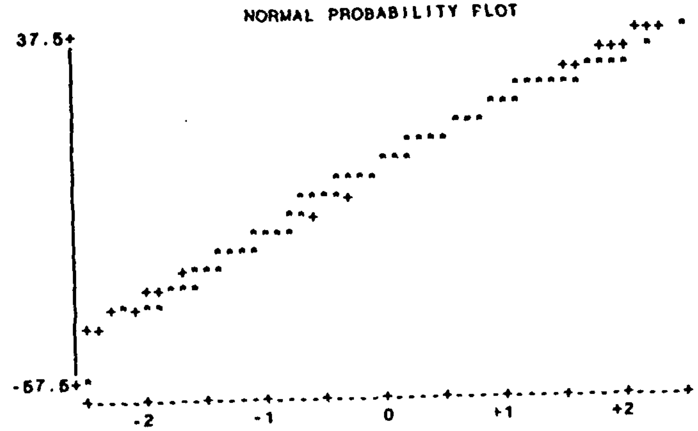
LOWEST	HIGHEST
-56.1518	26.3091
-37.2888	29.827
-36.3651	29.8488
-35.5109	32.9732
-34.9392	38.2761

```
STEM LEAF                    #
   3 8                       1
   3 003                     3
   2 5556                    4
   2 01111112233            11
   1 568889                  6
   1 00111111222333         14
   0 55566667778999         14
   0 1122333344             10
  -0 44443332221111000000   20
  -0 988887777755           12
  -1 211000                  6
  -1 99776666                8
  -2 432210000               9
  -2 888                     3
  -3 21                      2
  -3 7665                    4
  -4
  -4
  -5
  -5 6                       1
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 22 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.265E-14	SUM	2.899E-12
STD DEV	15.6541	VARIANCE	245.051
SKEWNESS	-0.322605	KURTOSIS	0.0467176
USS	31121.4	CSS	31121.4
CV	99999	STD MEAN	1.38364
T:MEAN=0	1.637E-14	PROB>|T|	1
SGN RANK	113	PROB>|S|	0.780052
NUM ^= 0	128		
D:NORMAL	0.0403887	PROB>D	>.15

QUANTILES(DEF=4)

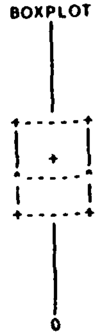
100% MAX	37.1729	99%	35.6635
75% Q3	11.0362	95%	25.2316
50% MED	-0.563013	90%	19.4181
25% Q1	-10.5446	10%	-19.4022
0% MIN	-44.5264	5%	-30.2396
		1%	-43.3347
RANGE	81.6993		
Q3-Q1	21.5806		
MODE	-44.5264		

EXTREMES

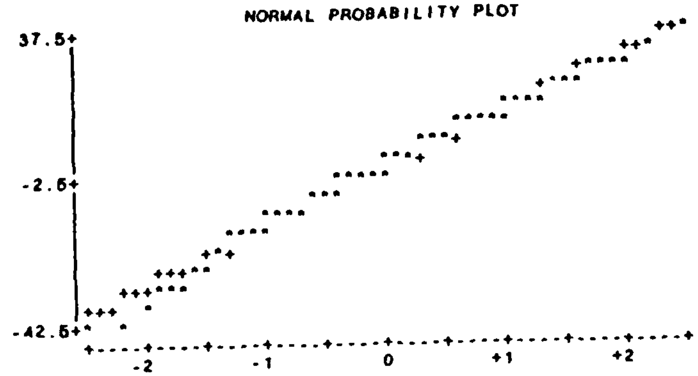
LOWEST	HIGHEST
-44.5264	28.3486
-40.417	28.6184
-35.6328	27.6301
-33.3896	31.9679
-32.8938	37.1729

```
STEM LEAF                    #
   3 7                       1
   3 2                       1
   2 56678                   5
   2 01122                   5
   1 55567888899            11
   1 00011123334444         14
   0 5555666777888899       16
   0 11222333                8
  -0 44444332221111111100   20
  -0 8888877655555          13
  -1 4444433211100          13
  -1 997766555               9
  -2 210                     3
  -2 776                     3
  -3 332                     3
  -3 6                       1
  -4 50                      2
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 23 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.442E-14	SUM	3.126E-12
STD DEV	17.748	VARIANCE	314.993
SKEWNESS	-0.232436	KURTOSIS	0.00861793
USS	40004.1	CSS	40004.1
CV	99999	STD MEAN	1.56872
T:MEAN=0	1.557E-14	PROB>|T|	1
SGN RANK	76	PROB>|S|	0.857506
NUM ^= 0	128		
D:NORMAL	0.0419983	PROB>D	>.15

QUANTILES(DEF=4)

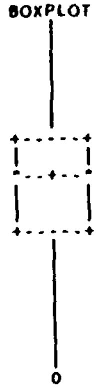
100% MAX	41.8886	99%	40.0468
75% Q3	12.3078	95%	31.12
50% MED	0.695597	90%	21.4395
25% Q1	-11.2702	10%	-23.1666
0% MIN	-51.3076	5%	-29.8819
		1%	-49.5185
RANGE	93.1962		
Q3-Q1	23.578		
MODE	-51.3076		

EXTREMES

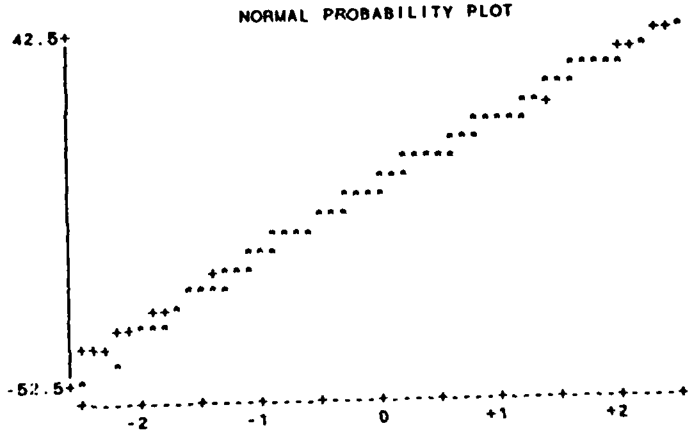
LOWEST	HIGHEST
-51.3076	31.6882
-45.1383	31.8617
-38.4987	34.0203
-36.5311	35.5377
-35.6363	41.8888

```
STEM LEAF                      #
   4 2                         1
   3 6                         1
   3 11224                     5
   2 5678                      4
   2 00012                     5
   1 66667778889              11
   1 01233444                  8
   0 5566677777888888999      19
   0 1223334444               10
  -0 433322222221110          15
  -0 998887555                 9
  -1 433211111100000          15
  -1 99876655                  8
  -2 32111                     5
  -2 988766                    6
  -3 1                         1
  -3 876                       3
  -4
  -4 5                         1
  -5 1                         1
     ----+----+----+----+
MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 24 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.037E-14	SUM	2.608E-12
STD DEV	16.0627	VARIANCE	258.011
SKEWNESS	-0.137626	KURTOSIS	-0.0724985
USS	32767.4	CSS	32767.4
CV	99999	STD MEAN	1.41976
T:MEAN=0	1.435E-14	PROB>|T|	1
SGN RANK	-3	PROB>|S|	0.995256
NUM ^= 0	128		
D:NORMAL	0.0551649	PROB>D	>.15

QUANTILES(DEF=4)

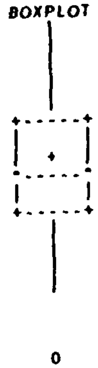
100% MAX	35.1018	99%	33.7617
75% Q3	11.5912	95%	28.1874
50% MED	-0.335005	90%	21.3373
25% Q1	-10.8075	10%	-22.0517
0% MIN	-50.439	5%	-25.9654
		1%	-45.4065
RANGE	85.5408		
Q3-Q1	22.3986		
MODE	-33.0857		

EXTREMES

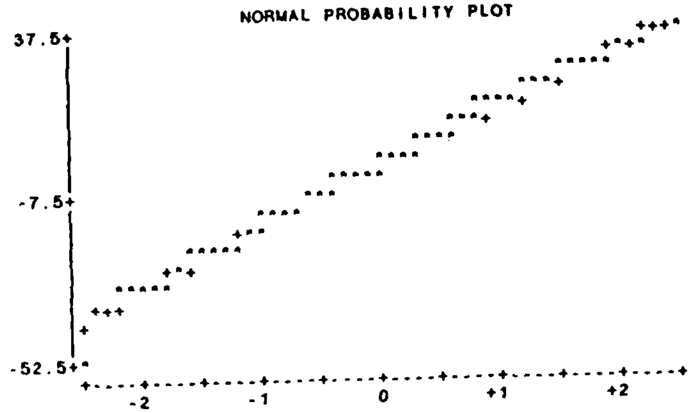
LOWEST	HIGHEST
-50.439	29.6106
-33.0857	29.6399
-33.0857	30.2893
-31.607	30.5499
-30.0458	35.1018

```
STEM LEAF                       #
   3 5                          1
   3 00001                      5
   2 5566                       4
   2 011122                     6
   1 555667778889              12
   1 012223                     6
   0 555667778888889           15
   0 1122223                    7
  -0 444333332211110000000000  24
  -0 9998877655555             13
  -1 4444432111000             13
  -1 966655                     6
  -2 432222111                  9
  -2 75                         2
  -3 3320                       4
  -3
  -4
  -4
  -5 0                          1
     ----+----+----+----+----
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 25 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.907E-14	SUM	2.441E-12
STD DEV	15.7324	VARIANCE	247.51
SKEWNESS	-0.0960863	KURTOSIS	-0.340639
USS	31433.8	CSS	31433.8
CV	99999	STD MEAN	1.39057
T:MEAN=0	1.371E-14	PROB>|T|	1
SGN RANK	63	PROB>|S|	0.881842
NUM ^= 0	128		
D:NORMAL	0.0717398	PROB>D	0.103

QUANTILES(DEF=4)

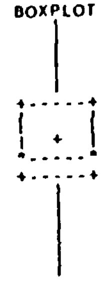
100% MAX	34.4735	99%	33.8955
75% Q3	12.3378	95%	24.7403
50% MED	-2.634	90%	20.1142
25% Q1	-9.54493	10%	-20.404
0% MIN	-46.9836	5%	-25.3236
		1%	-43.089
RANGE	81.457		
Q3-Q1	21.8827		
MODE	-6.74294		

EXTREMES

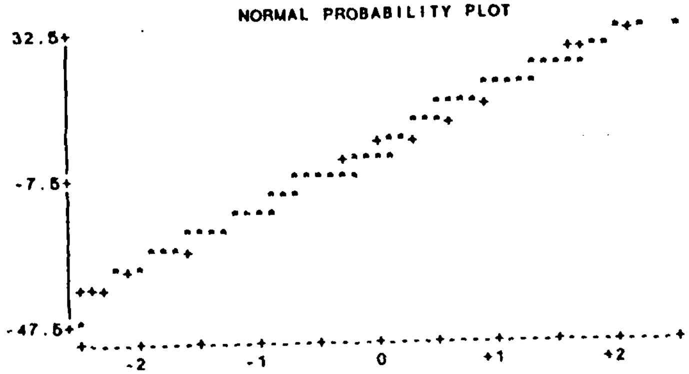
LOWEST	HIGHEST
-46.9836	25.0891
-33.5541	26.5781
-31.9043	31.1582
-28.6478	32.4805
-28.1276	34.4735

```
STEM LEAF                                #
   3 124                                 3
   2 55557                               5
   2 003344                              6
   1 5566667788999                      13
   1 0012222223334                      13
   0 556788889999                       12
   0 11244                               5
  -0 444333333222000                    15
  -0 999888888777777666655555           24
   1 4331100                             7
   1 98876666655                        11
  -2 3221100                             7
  -2 9865                                4
  -3 42                                  2
  -3
  -4
  -4 7                                   1
     ----+----+----+----+----
MULTIPLY STEM LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 28 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.765E-14	SUM	2.260E-12
STD DEV	16.0394	VARIANCE	257.262
SKEWNESS	-0.0365186	KURTOSIS	-0.718715
USS	32672.3	CSS	32672.3
CV	99999	STD MEAN	1.4177
T:MEAN=0	1.245E-14	PROB>|T|	1
SGN RANK	40	PROB>|S|	0.925159
NUM ^= 0	128		
D:NORMAL	0.0510268	PROB>D	>.15

QUANTILES(DEF=4)

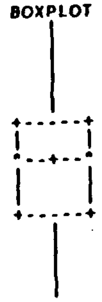
100% MAX	36.1233	99%	35.8218
75% Q3	12.5097	95%	27.0447
50% MED	0.949779	90%	21.0863
25% Q1	-13.1826	10%	-23.5071
0% MIN	-32.7875	5%	-28.4865
		1%	-32.3663
RANGE	68.9107		
Q3-Q1	25.6923		
MODE	-23.5071		

EXTREMES

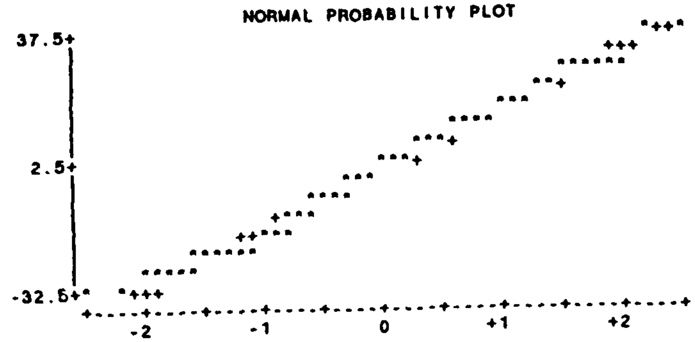
LOWEST	HIGHEST
-32.7875	28.1118
-31.3353	28.4304
-28.519	29.0002
-28.3699	35.0836
-28.3665	36.1233

```
STEM LEAF                    #
   3 56                      2
   3
   2 5568889                 7
   2 1124                    4
   1 5567788899             10
   1 0001122334444444       16
   0 5577777888999          13
   0 1111223333344          13
  -0 44422111100            11
  -0 88777777766665555      17
  -1 444333311               9
  -1 9988888                 7
  -2 44444333211            11
  -2 988755                  6
  -3 31                      2
     ----+----+----+----+
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 27 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	2.609E-14	SUM	3.340E-12
STD DEV	13.0702	VARIANCE	170.829
SKEWNESS	-0.0314851	KURTOSIS	-0.375137
USS	21695.3	CSS	21695.3
CV	99999	STD MEAN	1.15525
T:MEAN=0	2.258E-14	PROB>|T|	1
SGN RANK	-10	PROB>|S|	0.981975
NUM ^= 0	128		
D:NORMAL	0.058702	PROB>D	>.15

QUANTILES(DEF=4)

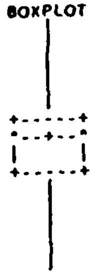
100% MAX	32.5629	99%	31.5421
75% Q3	8.58642	95%	22.1828
50% MED	0.657134	90%	18.4702
25% Q1	-9.99895	10%	-18.5729
0% MIN	-32.0772	5%	-23.8895
		1%	-30.6657
RANGE	64.6401		
Q3-Q1	18.5654		
MODE	-32.0772		

EXTREMES

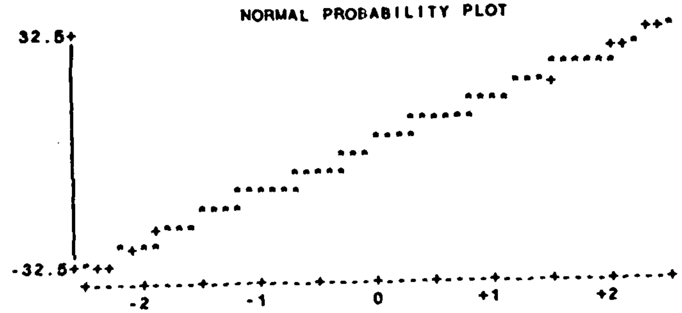
LOWEST	HIGHEST
-32.0772	22.868
-27.2101	23.9232
-25.8988	24.8508
-25.2697	29.0428
-24.8458	32.5629

```
STEM LEAF                        #
   3 3                           1
   2 59                          2
   2 0012234                     7
   1 5555899                     7
   1 000022223334               12
   0 555555555666778888888889999 24
   0 11112223444                11
  -0 4443222211100000           16
  -0 999888776555               12
  -1 414332221111111000000      21
  -1 97655                       5
  -2 43200                       5
  -2 7355                        4
  -3 2                           1
     ----+----+----+----+----
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 28 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.849E-14	SUM	2.366E-12
STD DEV	14.2523	VARIANCE	203.128
SKEWNESS	-0.144546	KURTOSIS	-0.294237
USS	25797.2	CSS	25797.2
CV	99999	STD MEAN	1.25974
T:MEAN=0	1.467E-14	PROB>|T|	1
SGN RANK	33	PROB>|S|	0.938393
NUM ^= 0	128		
D:NORMAL	0.0515097	PROB>D	>.15

QUANTILES(DEF=4)

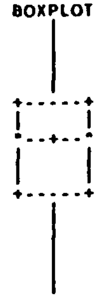
100% MAX	30.776	99%	30.5551
75% Q3	10.412	95%	22.4944
50% MED	1.2753	90%	19.1053
25% Q1	-10.2331	10%	-17.6236
0% MIN	-39.1622	5%	-21.624
		1%	-37.9295
RANGE	69.9382		
Q3-Q1	20.6451		
MODE	-17.7314		

EXTREMES

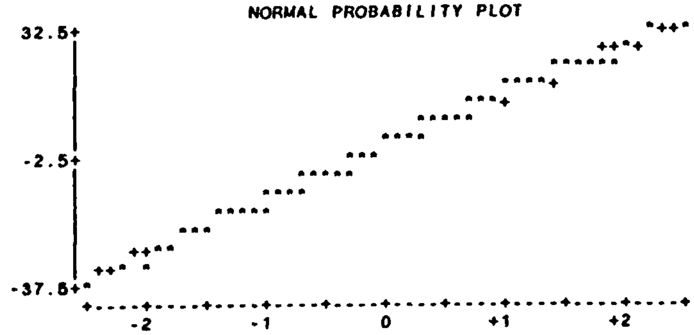
LOWEST	HIGHEST
-39.1622	23.9561
-34.9115	24.9189
-33.4397	29.1287
-27.9886	30.0141
-25.6027	30.776

```
STEM LEAF                 #
   3 01                   2
   2 59                   2
   2 0011134              7
   1 556668779999        12
   1 00111223344         11
   0 5555556777788889    16
   0 1111133333444444    16
  -0 4444443322110       13
  -0 999888877776565     15
  -1 443333322000        12
  -1 8888766655555       13
  -2 2210                 4
  -2 66                   2
  -3 3                    1
  -3 95                   2
     ----+----+----+----+
  MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



DAY 30 -- ANALYSIS OF RESIDUALS -- WITH ATTACK

UNIVARIATE

VARIABLE=YRESID RESIDUALS

MOMENTS

N	128	SUM WGTS	128
MEAN	1.585E 14	SUM	2.029E-12
STD DEV	12.9[illegible]78	VARIANCE	166.611
SKEWNESS	-0.364002	KURTOSIS	0.0241313
USS	2115[illegible].6	CSS	21159.6
CV	99[illegible]99	STD MEAN	1.1409
T:MEAN=0	1.389E 14	PROB>|T|	1
SGN RANK	70	PROB>|S|	0.686877
NUM ^= 0	128		
D:NORMAL	0.0563[illegible]85	PROB>D	>.15

QUANTILES(DEF=4)

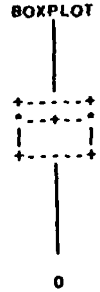
100% MAX	24.7286	99%	24.7066
75% Q3	9.40358	95%	20.6447
50% MED	0.557588	90%	18.4351
25% Q1	-8.54975	10%	-18.6635
0% MIN	-41.6686	5%	-23.0064
		1%	-38.6453
RANGE	66.3972		
Q3-Q1	17.9533		
MODE	-41.6686		

EXTREMES

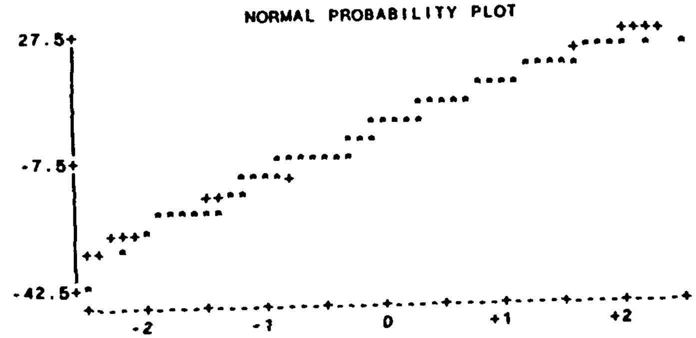
LOWEST	HIGHEST
-41.6686	22.338
-31.2434	23.2582
-28.0164	23.794
-24.3244	24.6534
-23.7122	24.7286

```
STEM LEAF                          #
   2 55                            2
   2 2234                          4
   1 5666677779                   10
   1 000122333333344              15
   0 555566677788888888899        21
   0 111111222334                 12
  -0 4433322211000000             16
  -0 9999999877777776666655       22
  -1 3333222000                   10
  -1 99655                         5
  -2 44333110                      8
  -2 8                             1
  -3 1                             1
  -3
  -4 2                             1
     ----+----+----+----+--
 MULTIPLY STEM.LEAF BY 10**+01
```

BOXPLOT



NORMAL PROBABILITY PLOT



VITA

VITA

David Alan Diener [redacted]. The son of a career Air Force officer, he traveled and lived throughout the United States as a child. After graduating from high school in 1971, he attended Michigan Technological University for one year before entering the United States Air Force Academy (USAFA). He was a Distinguished Graduate of USAFA in 1976 with a Bachelor of Science degree in Management and Economics.

Upon entering active duty in the United States Air Force, David Diener was assigned to aircraft maintenance officer positions at Moody Air Force Base, Georgia, at the Headquarters United States Air Forces in Europe, and at the Pentagon where he was a logistics system analyst.

In June 1980, David Diener was a Distinguished Graduate of the Air Force Institute of Technology (AFIT), receiving his Master of Science degree in Logistics Management. He received a Ph.D. in Management from Purdue University in December 1989. He is currently an Assistant Professor of Logistics Management at the Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio.